THE INSTITUTE OF PHYSICS

BULLETIN

CONTENTS

Theory, Measurement and Responsibility in Air Pollution . . . . . D. H. LUCAS 113

A Full-time Course for the Diploma in Technology L. R. B. ELTON 118

Forthcoming Institute Meetings 120

Physical Methods Applied to the Study of Visual Perception . . . . R. W. DITCHBURN 121

Notes and News 125

Branch and Group News 126

Correspondence 128

Reviews of Books 130

The Institute's Journals 135

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Qualifications: normally first or second class honours degree in science, mathematics or engineering, or equivalent attainment; additionally, for (*a*), at least 3 years' relevant (e.g. postgraduate) experience. Normal age limits: (*a*) between 26 and 31, (*b*) between 21 and 28, with extension for regular Forces Service and Overseas Civil Service. London Salaries (men) : (*a*) £1,233 – £1,460, (*b*) £655 – £1,150; provision for starting pay above minimum. Promotion prospects. Write Civil Service Commission, 17 North Audley Street, London, W.1, for application form, quoting (*a*) S53/59, (*b*) S52/59.

UNIVERSITY OF ABERDEEN

Applications invited for LECTURESHIPS and ASSISTANTSHIPS in experimental physics, theoretical physics, and electronics, all in the Natural Philosophy department. Salaries: Lecturers £900 × £50 – £1,350 (Bar) × £75 – £1,650; Assistants £700 × £50 – £850. All with F.S.S.U., child allowance and part removal expenses.

Particulars from the Secretary, The University, Aberdeen, with whom applications (8 copies for Lectureships and 2 copies for Assistantships) should be lodged by June 1, 1959. Applicants outside the British Isles may submit one copy of application.

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SENIOR SCIENTIFIC AND SCIENTIFIC OFFICERS required in Scientific Adviser's department. Qualifications: 1st or 2nd class honours degree in mathematics, statistics or physical science such as physics, engineering. Honours degree in natural or social science if candidate possesses at least mathematical knowledge at G.C.E. advanced level. Appointments offer great scope and interest to versatile Scientists capable of working well with Service officers and of adopting methods suited to Service environment. Work is mainly operational research in variety of subjects of concern to R.A.F. including tactics, technical development and logistics and offers Senior Scientific Officer and Scientific Officer entrants valuable experience in principles of operational research. Salaries London Senior Scientific Officer £1,233 to £1,460. Scientific Officer £655 to £1,150. Outside London slightly lower. Salaries for women being raised by stages to men's rates. Forms from M.L.N.S. Technical and Scientific Register (K), 26 King Street, London, S.W.1 (quoting A.163/9A/NB). Closing date May 25, 1959.

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Applicants should be of degree standard. Experience in the Iron and Steel Industry is desirable but not essential. Salary will be according to qualifications and experience. There is an up-to-date superannuation scheme and prospects of advancement are good.

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Salary : dependent on qualifications and experience within the ranges £A1,326 – 1,951 p.a. or £A2,061 – 2,336 p.a. Fares paid. Further details of duties, conditions, etc., supplied on application to Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Liaison Office, Africa House, Kingsway, London, W.C.2, to whom applications (quoting Appointment No. 770/172 RP) should be addressed by May 30, 1959.

WELSH COLLEGE OF ADVANCED TECHNOLOGY
DEPARTMENT OF APPLIED PHYSICS

Applications are invited for the posts of —(*a*) LECTURER, (*b*) ASSISTANT LECTURER (Grade B).

Candidates should have a good honours degree, together with teaching, research or industrial experience.

The salaries are as follows:—Lecturer—£1,260 to £1,417 10s. p.a. Assistant Lecturer (Grade B)—£682 10s. to £1,076 5s. p.a.

Application forms, together with further particulars, may be obtained from the Principal, at the College, Cathays Park, Cardiff, to whom they should be returned as soon as possible. Robert E. Presswood, Clerk to the Governors, City Hall, Cardiff.

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HOSPITAL PHYSICIST (Basic Grade) required for Kent and Canterbury Hospital, Radiotherapy Centre, Canterbury, for work on medical treatment with radio-isotopes, cobalt beam and other forms of ionising radiation. Facilities for research available. Senior Physicist in charge of department. Science degree in physics or equivalent qualification required. Experience of hospital or radiation physics desirable but not essential. Salary according to qualification—service and experience range £570-£1,035. Applications to be sent to the Hospital Secretary, Kent and Canterbury Hospital, Canterbury, as soon as possible.

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Commencing salaries will be in accordance with age and experience. Pension and Incentive Bonus Schemes are in operation. Assistance can can be given with housing.

Applications should be made in writing to the Personnel Manager.

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Applications are invited from PHYSICISTS with a Ph.D. or good honours degree with research experience interested in studying fundamental interactions in solids, by working with the paramagnetic resonance team of the Solid State Group of the Organization's Division of Physics at the National Standards Laboratory, Sydney. The group is studying electromagnetic absorption in paramagnetic substances, transport properties, heat capacity and expansion of solids and is developing a 21 cm. solid state Maser.

Salary : dependent on qualifications and experience within a minimum of £A1,400 p.a. and approximate maximum of £A2,400 p.a.

Initial appointment : two years. Fares paid. Details of duties, conditions, etc., on application to Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, to whom applications, quoting Appointment No. 770/172 F, should be addressed by May 30, 1959.

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SENIOR LECTURER OR LECTURER IN PHYSICS

Applications are invited for this position. It is hoped to make the appointment at the Lecturer level (salary £1,025 × £50 – £1,275 per annum) but an appointment would be possible at the Senior Lecturer level (salary £1,315 × £50 – £1,615 per annum) if suitably qualified applicant was available. Although experience in theoretical physics is regarded as a desirable qualification, candidates whose interests are mainly experimental are invited to apply.

Further particulars are available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or from the Registrar, University of Otago, Dunedin, New Zealand.

Applications close in New Zealand and London on May 31, 1959.

PORTSMOUTH COLLEGE OF TECHNOLOGY

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Applications are invited immediately for the post of Head of this Department (Grade IV)—Salary Scale £1,837 10s.–£52 10s.–£1,995, to commence duties on January 1, 1960. Applicants should possess high academic qualifications, and have had experience of full-time teaching, together with industrial and/or research experience. The Department is recognized by the Institute of Physics. The person appointed will be expected to develop further the already substantial volume of advanced work and to foster research work. Forms of application and further information available from the Registrar of the College.

SHIRLEY INSTITUTE

The British Cotton Industry Research Association, in a project sponsored and financially assisted by the National Research Development Corporation, is engaged on the application of modern scientific methods (particularly automatic control systems) to the spinning and similar textile processing of cotton and synthetic fibres and their blends. The work has already advanced considerably and reached an interesting stage and there is an urgent need for the recruitment of additional physicists and mechanical and electrical engineers whose work will lead to important developments in an old-established industry. Academic or professional qualifications are essential and for some of the posts industrial experience is desirable. The work offers a most interesting combination of academic and industrial research and there are ample opportunities for publication. There will also be engineering development work after satisfactory completion of the initial researches. Applications are invited for three types of appointment.

1. STAFF APPOINTMENTS are offered to physicists and engineers within the salary range of £700 – £1,250 (and upward for at least one more senior vacancy), plus superannuation benefits under F.S.S.U. ; the actual salary will be dependent on qualifications and experience.

2. FELLOWSHIPS are offered for two or three years on similar terms to the staff appointments but initially without superannuation. There will be opportunities for transfer from a Fellowship to a staff appointment.

3. GRADUATE APPRENTICESHIPS are offered to prospective corporate members of the Institution of Mechanical Engineers according to a scheme prepared in consultation with the Institution. Salaries will be up to £700 per annum with the opportunity to transfer to staff appointments with superannuation at the end of the Apprenticeship period.

Physicists or engineers are invited to communicate personally with full details to Mr. G. W. Lobb, Shirley Institute, Didsbury, Manchester 20, who will be pleased to arrange interviews for suitable candidates, expenses being met by the Association. This invitation is issued to anyone (including National Servicemen) available before December 31, 1959.

SUNDERLAND EDUCATION AUTHORITY

TECHNICAL COLLEGE

Applications are invited for the post of LECTURER in physics : duties to commence on September 1, 1959. Applicants should have honours degree ; research or industrial experience an advantage.

Salary : £1,260 × £31 10s. 0d. to £1,417 10s. 0d.

Further particulars and form of application from the Registrar, The Technical College, Sunderland. Canvassing will disqualify.

W. Thompson, Director of Education, 15 John Street, Sunderland.

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Theory, Measurement and Responsibility in Air Pollution*

By D. H. LUCAS, B.A., A.M.I.E.E., F.Inst.P.

(Central Electricity Research Laboratories, Leatherhead)

THEORY

As is usual in a scientific study, theory and measurement proceed hand in hand. Some kind of theoretical background is essential before any measurements can be made meaningful. This theory may be elaborate and detailed but it is astonishing how much insight can be obtained by postulating the simplest and crudest model and carrying out a little very elementary mathematics. The quantitative results will be approximate only, but progress to an accurate study usually needs a very complicated theory and difficult and laborious mathematics without giving much assistance to insight. In the study of air pollution some extremely simple theory helps enormously to clarify the subject. If we make the following assumptions :

1. pollution comes from chimneys;
2. it moves with the wind;
3. it spreads up and down and sideways;
4. that at a given distance from a chimney, the concentration of the pollution inside the " plume " is uniform.

then it follows as shown in Figure 1 that if the amount of pollutant emitted per second is X the height of the emission is H and the wind velocity is V that the concentration when the plume reaches the ground is

$$C = \frac{X}{\pi H^2 V} \quad \ldots \quad \ldots \quad (1)$$

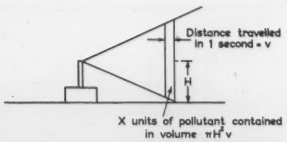

Fig. 1. *Simplified Representation of Spread of Pollution.*

and with the simplified model adopted this represents the maximum ground level concentration. It is interesting to record that with the much more elaborate analysis carried out by O. G. Sutton the corresponding form is

$$\frac{2}{e} \times \frac{X}{\pi H^2 V}$$

It is also significant that the form is independent of the particular rate of diffusion of pollution in the atmosphere. Although the maximum concentration produced is not the sole indication of the amount of nuisance being caused it is by far the most important single variable. This elementary formula indicates that pollution is reduced in three cases:

1. If X, the rate of emission, is reduced;
2. If H, the height of emission, is increased;
3. If V, the wind speed, increases.

The three main types of pollution are smoke, gas and dust. The ideal way of preventing pollution in the first case is indubitably to reduce X; in the second case to increase H and in the third case, which is the most difficult, it is essential in the case of power stations, for instance, both to reduce X and to increase H.

The dependence of concentration on wind velocity is somewhat more complicated than the simple formula suggests, because wherever the pollutant is emitted in a hot plume the effective height of emission is a function of the wind velocity and one of the first requirements of a more detailed study is to establish this function.

Indeed, this matter is too important to be left without some further theory. The plume rise due to buoyancy is inversely proportional to the wind speed raised to a power which has been given as high as 3 but is at least 1. i.e.

$$H = \frac{k}{v^m} \quad m > 1 \text{ (neglecting the height of the chimney itself for convenience)}$$

$$C = \frac{Xv^{2m}}{\pi k^2 v} = \frac{Xv^{2m-1}}{\pi k^2} \quad \ldots \quad \ldots \quad (2)$$

* Based on a paper read to the London and Home Counties Branch of the Institute of Physics and the Ewell County Technical College Faraday Society on October 1, 1958.

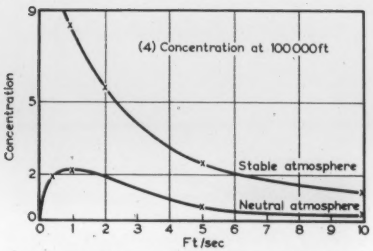

Fig. 2. *Typical Curves for Concentrations produced by Domestic Fires showing dependence on Wind Speed and Plume Rise.*

It follows that at low wind speeds, when the chimney height can be ignored compared with the plume rise due to buoyancy, that the maximum ground level concentration tends to *zero* and not to infinity as the wind speed tends to zero, provided the plume rise is not cut short by an inversion (see Figure 2). Hence the tendency for decreasing wind speeds to produce increasing ground level concentrations is reversed below a certain wind speed. The value of this critical wind speed varies from case to case. For domestic chimneys it is only a few feet per second and hence in general lower wind speeds produce higher concentrations. For large chimneys with hot plumes the value is an order higher and for most of the normal range of wind speeds, concentrations at ground level decrease as the wind speed falls.

To return to the simple model, it follows that on any given occasion a pattern of pollution at ground level is produced similar to the pattern shown in Figure 3 (The detailed shape can of course only be assessed by a more elaborate model.) It also follows, if we take

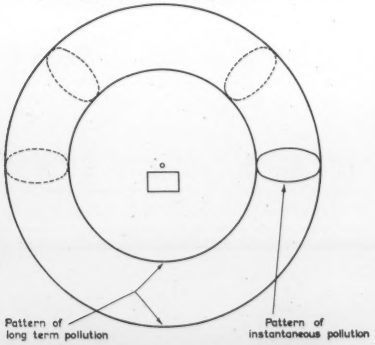

Fig. 3 *Instantaneous and Time Mean Pattern of Pollution*

account of the variation of wind direction from day to day, that over a long period the pattern of pollution is like the long term pattern shown in Figure 3. Some very simple observations on the spread of plumes, coupled with some simple figures on wind direction establishes that the concentrations of the second pattern are usually at least thirty times less than the concentrations relevant to the first pattern. This important factor must be remembered when comparing quoted concentrations. Their significance depends greatly on whether they are instantaneous concentrations or long term averages. The factor may well be a larger one if in addition to allowing for changes of wind direction, variations of wind speed, emission rate and so on are allowed for. This simple pattern also emphasizes the fact that pollution is a local problem. In the Beaver Report the quantities of pollution emitted on a national scale were listed. This suggested by implication that the quantity of emission without regard to locality or height of emission is a measure of the nuisance value caused. If the country as a whole can be represented by the model of a number of smokers in a closed room then this approach would be justified, but this model bears no resemblance to the facts and pollution is essentially a function of height of emission, locality and concentration of sources in the locality as well as the quantity of emission.

In an attempt to obtain more precise information than is given by the simple theory already discussed it is well known that Sutton, Bosanquet, Priestley and others have produced theories both about the diffusion of pollutants in the atmosphere and also concerning the dependence of plume rise on wind speed and other factors. These theories have not been as beneficial as they might have been because they have contradicted one another and because they have not been adequately supported by measured results. It is probable that at the moment progress depends more on obtaining measurements to test the various theories current than on any development of theory.

MEASUREMENT

The standard sulphur candle has been available for many years and probably gives a useful indication of the mean monthly concentration of sulphur dioxide at a particular point. The variations both in the source of pollution and in the weather conditions which take place during a month are so complicated that it is virtually impossible to make use of the sulphur candle results in assessing the forecasts of different theories. They have been used fairly widely around power stations and the results obtained before and after the station operates have at least indicated that the high chimneys with which large modern stations are provided are effective in preventing objectionable ground level concentrations.

A new instrument has been developed at the Central Electricity Research Laboratories[1] which enables the concentration of the sulphur dioxide in the air to be measured in parts per hundred million and gives a measurement in about one minute. It can be used to measure the variations of concentration that take place from time to time and should greatly improve our insight into the theory. Even so the amount of labour involved is very considerable and it may prove difficult to separate the effects which are due to the diffusion mechanism in the atmosphere and those which are due to the increase

of the effective height of emission when the wind speed changes or the amount of heat in the plume changes. A further technique has, therefore, also been developed at Central Electricity Research Laboratories to measure the height to which the plume from a power station rises under various conditions.[2] The basis of the technique is partially to inflate a polythene balloon with hydrogen and to adjust its weight until it is exactly buoyant in air (Figure 4). It is then introduced into a

Fig. 4. *Balancing of Balloon.*

power station chimney, Figure 5, and allowed to move through the atmosphere with the flue gases. Its path is recorded by means of a range finder on an adjustable mount, Figure 6, which enables the range and the angle of elevation of the balloon to be noted simultaneously as the balloon moves away. By releasing a sufficient number of balloons the behaviour of the plume can be recorded for a range of circumstances. A typical result is shown in Figure 7. The technique has already given valuable information on the dependence of plume rise on wind velocity and is now being used to show the dependence of plume rise on the amount of heat leaving the chimney per second. It is hoped to publish the results shortly.

The technique has possible further applications in studying the deposition of dust from plumes in which case the balloon would be adjusted to have the same free falling speed as the dust being considered.

Considerable numbers of measurements on dust deposition round power stations have already been made using the standard deposit gauge. These results have shown that in addition to the variables which

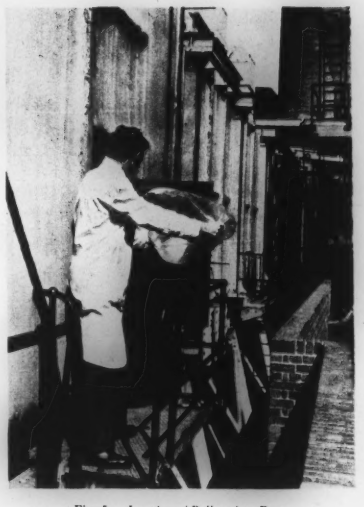

Fig. 5. *Insertion of Balloon into Duct.*

affect the concentration of gas an increase in the free falling speed of the dust has a very powerful influence in increasing the likelihood of dust nuisance at ground level.

A review of air pollution would be incomplete if it ignored the fog disaster in London in 1952, which concentrated public attention on air pollution. The incident was an exceptional circumstance but it focussed attention on a general problem It had all the existing uncertainties on air pollution and a few additional ones of its own. The cause of the many deaths is still not publicly established and in consequence there is no evidence that the Government action which followed has in any way minimized the risks of recurrence.

It is clear that the rise of plumes was restricted by the overlying inversion (the excluded case in the discussion of equation 2) that the $\frac{1}{V}$ term in equation 1 became increasingly large.

It has been established recently[3] that not all plumes were restricted. It had been considered possible for some time that large plumes might penetrate inversions and escape. A calculation made at C.E.R.L. in 1956[4] supported this on paper and recently a plane flight organized by the Central Electricity Generating Board confirmed that during a period of strong inversion with a fog layer 700 ft. thick, power station plumes penetrated the fog and escaped from the stagnant pool of polluted fog over London. The plumes were deliberately coloured and intensified so that identification was certain.

Fig. 6. *Balloon tracking.*

Measurements in the field are important but are laborious and time consuming. It is to be hoped that when the theoretical situation has been established that measurements at the power station (or other source of pollutant) will be sufficient to enable complete information on the likelihood of nuisance from power stations to be assessed. A type of instrument already in use is the instrument which measures the optical density of flue gases as they leave the power station. These instruments have very severe limitations not the least of which is that their observation windows tend to become obscured and to falsify their readings. A new design of observation window has been made at Central Electricity Research Laboratories[5] which has largely overcome this particular disability. However, there are also objections in principle to the use of this type of instrument for checking the dustiness of flue gases from power stations. It tends to take more notice of fine dust particles and less notice of coarse dust particles whereas it is well known that coarse dust particles are more likely to cause trouble in the neighbourhood of power stations. A new type of instrument has, therefore, been developed at Central Electricity Research Laboratories[6] which has been specifically designed to have a greater response to coarse particles than to fine. This is achieved by a special design of sampling head which collects a sample over a specified time. The final measurement is still made by light beam and photocell. Particular attention has been given in the design of the instrument to minimizing the errors often found in photocell instruments due to variations in light intensity, power supply voltage and photocell sensitivity.

The emission of sulphur dioxide can also be measured, but it is relatively easily calculated from the rate of combustion of coal and the coal sulphur content so a specific instrument is hardly called for.

RESPONSIBILITY

It is generally recognized that the air of our towns and to some extent of our countryside is polluted. It is not so generally realized that we do not know who is responsible. The study of air pollution is as complicated a "Whodunit" as any detective story and it will no doubt have at least as many surprises as to who is guilty and who is innocent. The power station has often been given the role of suspect No. 1. It is a feature of the policy of supplying power stations with high chimneys that the very action which was taken to reduce pollution, frequently arouses suspicion. A high chimney is conspicuous for a very long way, and a plume which is lifted high in the sky is much more clearly seen than one which is creeping into the observers lungs. However, as in the crime story the most obvious suspect is not always the one who ultimately stands in the dock.

One of the reasons for the uncertainty in detecting the source of pollution is that the standard instruments—the sulphur candle and the deposit gauge are non-directional—they indicate the pollution at a point—they do not indicate its direction of origin.

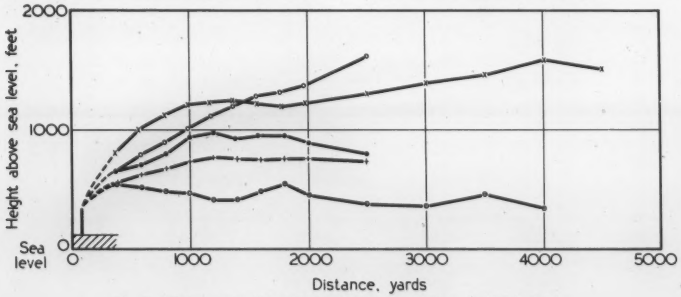

Fig. 7. *Balloon tracks 1300-1500 hours. Weather cloudy, mean wind 22·5 ft./sec.*

This is being corrected by techniques now being developed. The sulphur dioxide recorder[1] used in conjunction with an instrument for recording wind direction is an instance. This is a powerful but somewhat laborious technique. In the case of dust pollution, a very simple dust gauge[7] developed at Central Electricity Research Laboratories will give a monthly result divided among the four cardinal directions according to the direction of origin of the dust.

This gauge was developed because of the limitations of accuracy of the standard deposit gauge[8] and also because of weaknesses in principle. The results obtained by a dust gauge should give a clear indication whether the dustiness of the district is objectionable or not. In fact the standard gauge gives the weight of dust falling on a horizontal surface. This would be closely correlated with the likelihood that roofs would collapse due to excessive dust loading but this is rarely relevant to complaints of dustiness. (Note: At one time the author would have said never but he has found that rarely is more correct !). The weight of the settled dust is not of importance but the dirtiness or optical obscuration is. Again, complaints rarely arise because horizontal surfaces are affected by dust. More commonly vertical surfaces, such as windows, walls, bushes, etc., are obscured by dust. The particular case of the partly open window is again much better represented by a vertical than a horizontal surface. The new design of gauge is intended to overcome all these limitations as well as indicating the direction of origin of the dust.

Theoretical methods can also help in assessing responsibility. A recent calculation,[9] using basically the diffusion formula of Sutton has shown that the concentrations of pollutant produced by domestic grates in densely populated areas are collectively serious. See Figure 8. The estimated mean concentrations of SO_2 and smoke in the London area produced by domestic fires are approximately equal to the mean measured concentrations. Industrial pollution will doubtless make a contribution to sulphur dioxide concentrations which at the moment cannot be accurately assessed but it appears likely that considering the overall pollution, it will be a minor one compared with the domestic contribution.

The history of air pollution shows, like most history, that human beings are often irresponsible. The subject is a complex of politics, emotion and science. Without a political and emotional awakening there would have been no progress towards clean air. Equally unless the reformers have a responsible attitude, guided more by science than by emotion, the progress may well be retrograde. In the past accusations of air pollution have been directed more by indignation than by factual evidence and respectable industrialists and power station superintendents have been literally accused of murder, by men who at other times sat innocently by their open fires. It is to be hoped that in the future more responsibility will be shown and that accusations will only be made when they can be backed by scientific evidence rather than popular fallacy.

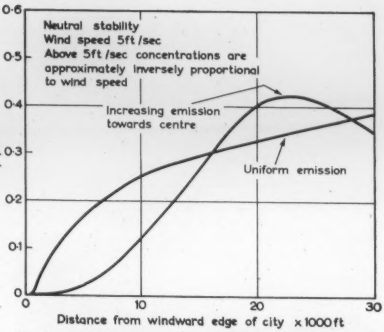

Fig. 8. *Level of Pollution across 30,000 ft. City with constant Emission and with increasing Emission towards Centre.*

Of course a responsible attitude is also essential on the part of the large industries. They could in the past claim with some justice that they could only stop pollution by stopping production since not enough was known about amounts of pollution or about preventive measures. This is rapidly becoming less and less true and responsible industrialists, both nationalized and independent are devoting money and effort to assessing the pollution they cause in their neighbourhood and to reducing it by using the considerable technology of prevention now available.

This is and will be the pattern of events in air pollution. As knowledge increases, irresponsibility both by the consumer of fuel and by the clean air advocate becomes progressively more difficult. Theory and measurement are inevitably followed by a feeling of responsibility in both its senses, and responsible action reduces air pollution.

(Figures 2 and 8 are reproduced from the *International Journal of Air Pollution* by permission of Pergamon Press. Figure 7 is reproduced from the *Quarterly Journal* by permission of the Royal Meteorological Society.)

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A Full-time Course for the Diploma in Technology

By L. R. B. ELTON, Ph.D., F.Inst.P.

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One of the minor irritations that I am subjected to arises whenever I mention to anybody that we at Battersea teach the Dip. Tech. "Oh, you mean the sandwich scheme, where they spend six months in every year in industry" is the general reply to this. I then patiently explain that this is not what I mean, but that our course is called either a full-time one or a thick sandwich course, depending how one looks at it, and that it consists of three full years in college with an industrial year between the second and third college years. What is the reason for this unorthodoxy or, as I prefer to think of it, why are we playing at little Johnny, who is the only one in step ?

The most important reason is that we think it educationally preferable. It is important to stress that here I am speaking purely of courses in physics and that quite different considerations may conceivably apply to, say, engineering. But in physics a boy straight from school has still so much groundwork to cover, that he is likely to find it very difficult to profit from experience in industry and to integrate this experience with his academic work. This opinion—and at this stage of the Dip. Tech. it cannot be more than that—is borne out by the fact that many firms refuse to take physics students for vacation work until they have been two years at college. I am convinced that this is not because the students are of little use to the firms until then, since vacation students rarely are of real use to a firm anyway, but because they are of little use to themselves.

We shall proceed then on the assumption that it is difficult to integrate the academic with the industrial work at the beginning of the course. It then follows that a long uninterrupted period of academic studies has very real advantages. The student settles down to learn physics, and also mathematics, and after two years he really knows something about the various branches of his subject. Now is the time for him to go into an industrial firm and to apply his knowledge to the problems arising in practice. These have a disconcerting way of involving ideas from all branches of physics at once and it is for this reason that the previous general grounding is so important.

During his second year the student has to make up his mind about the type of industrial experience that he would prefer and we try our best to find him something suitable, both as regards his interests and his abilities. We now know him quite well and he has probably spent a vacation in industry. This is not in actual conflict with what has been said before since many firms do in fact take students after their first year for vacation work. Even if they do not learn much physics in that time, they learn something about the differences between work in college and in industry and they begin to form their ideas about their future profession. It should, therefore, be possible at this stage to achieve a good match between student and industry without too much difficulty. He may spend the whole year at one place or he may spend six months in each of two places, but it is generally accepted that the settling down period is so long that anything less than six months would be valueless. During this year the student does not engage in any formal academic studies, although it is hoped that his industrial experience will stimulate his theoretical interests.

The final year of the course is much more specialized than the earlier ones, and each student is encouraged to specialize in the direction in which his industrial experience has taken him. We are speaking here of the future, since the course is in fact only in its second year and the first students will go out to industry in the summer of this year. The intention is, however, that there will be a common core of advanced electricity and electronics and that the special subjects, which must to a certain extent depend on the specialities of the staff, will be chosen from

(*a*) instrumentation and automatic control,
(*b*) deformation of metals and general rheology,
(*c*) X-ray technology,
(*d*) applied acoustics.

An extended project will be an important part of this final year. We shall say more about the project later.

At this point the subject of examinations must be mentioned. The final examination is divided into two equal parts, to be taken at the end of the second and fourth year and there are examinations in languages, liberal studies and mathematics. These latter are pass examinations which affect the final class only in borderline cases.

The time-table of examinations has been designed so that under normal circumstances a student is free from examination worries during his industrial year. Should he, however, have failed any examination during his first two years, he can make up for his failure during the industrial year and re-sit at the end of that year. The work of the final year is built upon that of the previous years, but we are accepting the fact that it is permissible to forget a great deal of knowledge once it has been learnt, provided only one knows where to find it again. The examination at the end of the course will therefore deal primarily with the specialized work covered during the last year.

All this has a strong influence on the form that tutoring during the industrial year should take. There is no need for intensive supervision designed to prepare the student for a coming examination, and the main duty of the tutor is to see that the industrial work is of the right standard and that the student is profiting from it.

Particularly during the formative years of the course, when both college and industry are trying to discover how best to shape the industrial year, this duty is a most onerous one. A special case is the student who is trying to make up a subject and who will require more intensive tutoring.

An objection that will undoubtedly be raised now is that most of the course is designed to keep the academic and applied sides apart instead of integrating them. If integrating means running the two simultaneously then certainly this is so. Such integration is surely not feasible since, as has been pointed out earlier on, almost every bit of application requires some knowledge of all branches of the academic side. For that reason basic theory and experiment must come first and any attempt to dovetail the academic and the practical side right from the start seems to me quite unfeasible and fundamentally unsound. At a later stage such dovetailing is not only possible, it is imperative. Once a student has his basic knowledge and has learnt of the conditions under which he must apply them in industry, he is ready for true integration which we attempt to achieve in the work of the final year and particularly in the project. This consists of a piece of original research, or at least original as far as the student is concerned, which stretches over most of the final year. At this stage when no student has as yet started on a project, it would be premature to go into any detail, but it is already clear to us that project work will be expensive in both staff time and in material costs. It is to be hoped that this will be recognized by those who control both.

So far I have justified our choice of full-time course on largely curricular grounds, but there are also far from negligible other advantages to teacher, student, and—last and I suppose least—administrator. For the teacher one main advantage is undoubtedly that his terms are synchronized with university terms, so that he is free at the times when courses and conferences take place. He also has a long period in the summer when he can conduct research without the daily disturbances that occur in term time. Such things must presumably be much more difficult to arrange, where thin sandwich courses, now with increasing frequency of the end-on type, are involved. It is surely significant that the great technical institutions in the United States, in Germany and elsewhere offer working conditions to staff and students which are indistinguishable from those in universities. It is for that reason that I say that it is we who are in step—in step with, although twenty steps behind—M.I.T. and California Institute of Technology and E.T.H. Zürich.

The advantages to the student are not unlike those to the teacher. Particularly in a university town it helps to keep university terms and a student should have a Long Vacation during which he can sit back and think, or hitch-hike to Italy. No lacing of the curriculum with liberal studies can make up for that. Another very substantial advantage has been mentioned before. It is that the student is considerably more mature by the time he has to make up his mind as to which industry he wishes to enter. This is of course true only of the college based student. The difference between his position and that of the industry based student will be discussed below.

To see which type of course is easier to administrate, one would have to try both, which I have not done. I will not therefore make any comparisons, but shall merely refer to the administrative difficulties connected with the tutoring of students in industry. This is comparatively easy when industry, college and also possibly the students' homes are all in the same locality. But a C.A.T. is to be a national institution, drawing students from the whole country and sending them to firms spread over the whole country too. Under such circumstances intensive tutoring is utterly impracticable and fortunately, as indicated above, also unnecessary in the case of thick sandwich courses.

An interesting consequence of the way our Dip. Tech. course has grown really also comes under the heading of ease of administration. Just because the terms are the same as those of the university it has been easy for us to continue running the internal London degree course in parallel with the Diploma course. We therefore have students of both types and one of my most interesting and very difficult tasks is to channel applicants into the right courses. How successful I am in this it is far too early to tell, but of one thing there can be no doubt—the mixing of the two types can only be for the good of both. It has been quite amazing to see how quickly the Diploma students are developing new and different traditions from the degree students in such matters as for instance works visits and vacation work, and how now the two traditions are beginning to react on each other. There is also the case of liberal studies. These are of course part of the Diploma course, but are quite outside the degree course. Nevertheless, in an entirely voluntary class for the first year of the degree course the attendance has been consistently around 60-70 per cent.

We next turn to the attitude of industry. A year ago I sent a circular letter to a large number of firms, explaining our way of teaching the Dip. Tech. and inviting their co-operation in running the industrial year. The response has been such that I have not been able to supply students to all the firms willing to take them this year, and the same may well be true next year, but once the course is running to capacity I foresee that I shall need additional offers. I feel very strongly that industry here is acting in a truly public spirited manner, since the student who does his industrial training with a firm is in no way bound to return to that firm after the completion of his course, though he may well wish to do so if he found the work attractive. On the other hand industry pays the college based student for only one of the four years he is studying, the other three years being covered by County or State grants.

There are in fact three types of students from the point of view of sponsorship. The first and so far most common, comes straight from school on a grant and spends his industrial year with a firm selected for him by the college. The second type, and there have been a few of these, has been released from industry and his firm is willing to take him back for his industrial year and also hopes that he will come back at the end of his course. On the other hand, his three college years are financed by a grant and he is actually under no compulsion to

spend the industrial year with his firm. The third type so far has failed to put in an appearance. It is the industry based student sponsored by his firm which pays for the whole four years of his study and also expects him to spend his period of industrial training and perhaps a long vacation with it. Such a student might either have been with the firm for some years or else he may just have left school at eighteen and be selected by a firm to be sponsored for such a course, in the same way as many firms now sponsor students for full-time degree courses. Perhaps the lack of such students at present is due to the fact that not many firms at the moment know about the possibility of full-time Dip. Tech. courses. In that case I hope that this article may remedy the situation.

So far very little has been said about the contents of the course. In many ways it appears to be not unlike the degree course, in which ways does it differ ? To start with it must be stressed that, as we are frequently informed, one course is to be as good as the other. While steering well clear of any attempt to define " as good as " in this connection, I feel that this gives a justification for the fact that in many ways the courses are similar. Perhaps a better justification is that there is only one Physics. At any rate, for the first two years the syllabuses of the two courses, both in physics and the ancillary mathematics, are not very disparate, the difference being largely one of emphasis. This shows up in lectures, laboratories and examinations, but it cannot be reduced to a few simple rules. To appreciate it, it would really be necessary to sit through the courses. In the final year the differences will increase considerably and in outline they have been mentioned before. In detail we shall not know what they are until we come to teach the students, for whether we are theoreticians or experimentalists in physics, in education we are all empiricists. In fact one of the to me refreshing changes in going from university to College of Advanced Technology has been the great interest I have found in the latter in methods of teaching and in education in general.

This article is a mixture of brief experience and long hopes. It is very much an interim report and in three years time I may come to write very differently. But at present I feel that we at Battersea are backing the right horse by teaching full-time courses. For technological education is not technical training, it is university work. And so it should be done in a university manner.

Forthcoming Institute Meetings

Date	*Place*	*Speaker*	*Title*	*Time*	*Branch or Group*
May 14	**Liverpool** The University	Mr. J. M. Craddock (*Meteorological Office*)	Branch Annual General Meeting followed by a lecture on : **Long range weather forecasting**	7.00 p.m.	Liverpool and North Wales
May 22	**London** The Institute's House	Dr. W. R. Harper, F.Inst.P.	**The tribo-electric effect**	6.00 p.m.	Non-Destructive Testing
June 2	**Hailsham, Sussex**		Branch summer visit to the Royal Greenwich Observatory, Herstmonceux Castle. All places have now been filled.		London and Home Counties
June 17 to 19	**Keswick** Armathwaite Hall, Bassenthwaite		**Summer Conference**		Non-Destructive Testing
June 19	**Shrivenham**	Dr. C. E. Wynn-Williams (*Imperial College of Science and Technology, London*)	Visit to the Royal Military College of Science, followed by a lecture on: **An introduction to electrical logic**		South Western

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Physical Methods Applied to the Study of Visual Perception*

By Professor R. W. DITCHBURN, M.A., Ph.D., F.Inst.P.

(*University of Reading*)

INTRODUCTION

THE study of visual perception is rightly regarded as primarily the concern of the physiologist yet the work described below may reasonably be classed as applied physics for two reasons. Firstly the experimental methods are clearly applications of physics and secondly the interpretation of the results is by analogy with physical control systems such as servo-mechanisms.

To the physicist, the eye is equivalent to an optical system which forms an image of the external scene upon a mosaic of receptors. Nearly all theories of visual perception before 1940 assumed that each receptor transmits to the brain a signal proportional to the light flux which it is receiving. The visual perception system was regarded as equivalent to a photocell connected through a d.c. amplifier to a calculating machine (Fig. 1a). However, there are very beautiful electro-physiological experiments which show that when a receptor is subject to steady illumination the signals in the associated nerve-fibres are very weak. Strong signals are obtained when a receptor is first illuminated and again when the illumination is cut off. The physical analogy is a photo-cell connected into an a.c. amplifier with a good response for frequencies in the range 3 c/s up to about 20 c/s (Fig. 1b).

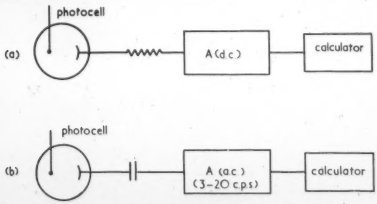

Fig. 1. *Schematic models of visual perceptor system : (a) d.c. transmission, (b) a.c. transmission.*

Detailed investigation has shown that this response to on and off rather than to steady illumination is characteristic of one of a group of receptors rather than to a single one which has been completely isolated. However, in our present situation we shall be considering receptors in the middle of the retina so the behaviour is likely to be as described above. Let us therefore assume that the signal transmitted is a function of dE/dt rather than of E (where E is the illumination) and see how eye movements are needed to maintain normal vision.

Suppose that a subject views a simple object as shown in Fig. 2a. An image of this is formed upon his retina. If he could hold that image permanently on the same part of the retina those receptors which correspond to points on the right of the line would receive strong steady illumination and those corresponding to points on the left would receive zero. Since both would be under constant illumination, accommodation would occur ; the signals received from the light part would fall rapidly to a very low value, because dE/dt would be zero over the whole field. If, however, the eye were to scan slightly from side to side, then those receptors corresponding to points in the image near the boundary between black and white would be stimulated by a series of on and off signals so that we should be able to distinguish the boundary. Extending this idea to more complex patterns, a suitable type of eye movement can convert spatial gradients dE/dx into temporal gradients dE/dt. In this way it is possible to distinguish difference of illumination in the pattern and the brain receives the information required to construct its picture of the external scene.

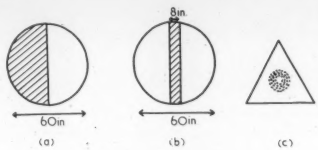

Fig. 2. *Visual targets.*

If this theory of visual perception is correct, then movements of the retinal image across the retina are essential for normal vision in conditions of steady illumination. It is, however, well known that we can see tolerably well even when we try to look as steadily as possible at an object (though vision under this condition is not quite as good as when the eye is allowed to move in a natural way). The experiments which will be described show that however strongly we try to fixate a target, certain small involuntary movements of the eye still remain. These provide the necessary scanning to maintain nearly normal vision. We shall also describe an optical servo-system which holds the image on the same part of the retina, even when the eye moves (we call this a *stabilized retinal image*). It is found that when the subject views this stabilized image there is a significant loss of visual discrimination. The retinal mosaic of receptors is so fine in the region near the centre that a rotation of the eye through less than half a minute of arc is sufficient to sweep the pattern from one set of retinal receptors to another. It is therefore necessary to have a method of observing eye movements which is capable of picking up a tremor whose amplitude is considerably less than a minute of arc and whose frequency, as we shall see later, is of the order of 5 to 200 cycles per second.

* A lecture given to the Manchester and District Branch of the Institute in Manchester on January 19, 1959.

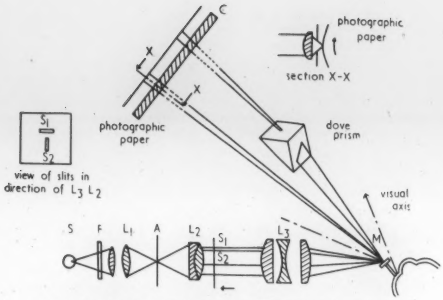

Fig. 3. *Apparatus for recording eye movements. The beam of light reflected from the mirror on the contact lens is split into two parts. One goes direct to the drum camera to record rotations in the plane of the paper. The other is rotated through $\pi/2$ by the Dove Prism and records rotations in the vertical plane. A more elaborate system also records rotations about the visual axis.*

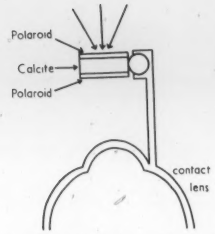

Fig. 5. *Optical Interferometer on Contact Lens.*

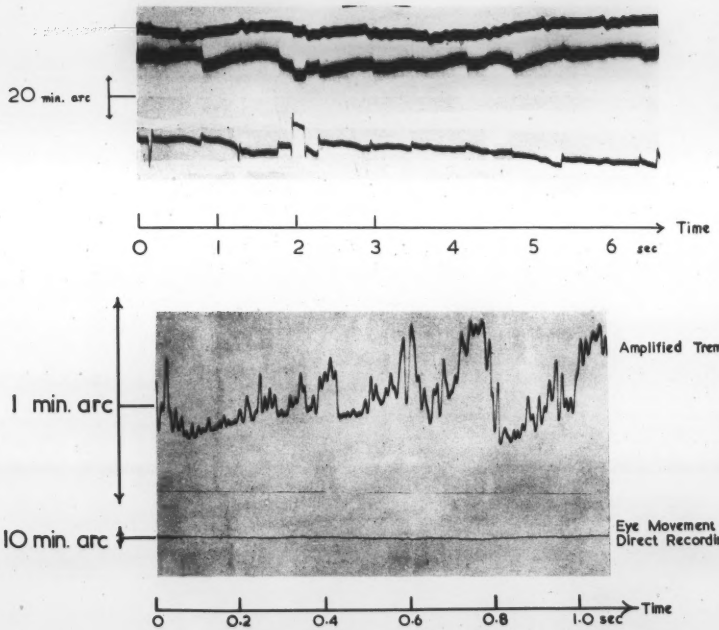

Fig. 4. *Records of Eye Movements: (a) Upper record shows (i) rotations in horizontal plane, (ii) in vertical plane and (iii) about visual axis, (b) Lower record-amplified tremor—note change of scale.*

EYE MOVEMENTS

To record eye movements[1] a contact lens is put on the subject's eye and a stalk extends from the contact lens with a mirror whose plane is normal to the optic axis. A beam of light reflected from the mirror on to a drum camera enables us to record movements of the eye in the horizontal plane. The more elaborate apparatus shown in Fig. 3 enables simultaneous records to be made of horizontal and vertical rotations and also of torsional rotations about the optic axis. Fig. 4a shows a record obtained with this apparatus. We can see the presence of very small drifts occurring at a rate of the order of one minute of arc per second and occasional large, very sharp flicks of up to ten minutes of arc. On this kind of record it is just possible to see the presence of a very fine irregular tremor movement but this is shown better in Fig. 4b. D. H. Fender obtained this record by allowing the beam of light reflected from the mirror to form an image of a grid. This image falls upon another grid placed in front of a photocell. The output from the photocell passes to an amplifier whose response increases rapidly with frequency (over an appropriate range). It therefore amplifies the fine rapid tremor while ignoring the slow drifts. It also effectively ignores the flick movements. The result, shown in Fig. 4b, leaves no doubt of the existence of a tremor movement whose amplitude is of the order of a fifth of a minute of arc. Fourier analysis of the records shows a frequency spectrum extending up to 200 c/s.

We now have the following picture of the way in which eye movements assist visual perception. The tremor vibrates the edges of objects across the retinal receptors, thereby stimulating the on and off signals in the nerve fibres associated with those receptors which lie near the edge between black and white, or where there are strong gradations of illumination. If the tremor were the only movement, then one set of receptors would be carrying information to the brain all the time and others would be doing very little. It is therefore more efficient to allow the retinal image to drift a little and it is advantageous to allow it to drift continuously in one direction so that the edge comes to new receptors which have not been strongly stimulated. If, however, the drift movement went on uncompensated for too long, then the point in the external scene in which we are most interested would drift away from the centre of the retina where the receptors are best. It is therefore necessary to have a re-centring device and this is provided by the very rapid flicks. On this view successive drifts should be random in direction but one direction should be maintained during the period between two flicks and this is found to be the case. The flicks also should not be random in direction but should tend to re-centre. A majority of the flicks do this; in fact they somewhat overshoot the centre.

Finally, it is desirable that the subject should not see the flicking movement, because if he did the world would appear to be moving in a series of jerks. Fender has arranged that the flicking movement shall generate a pulse which produces a pip on the display in a cathode ray tube. It is found that the person whose eye causes this pip cannot see it, although an observer sitting beside him sees it clearly. It thus appears that there is an inhibitory mechanism which operates during the flick to prevent us from seeing the flick, or rather from seeing the external world apparently moving in a series of jerks. Mackay has shown that a subject cannot detect small differences in target position provided that the target is not seen while in motion.

1. Eye movements have been studied by several workers (see references).

THE STABILIZED RETINAL IMAGE

Let us now consider how a stabilized retinal image may be produced. This has been done in two ways. The first, which is shown in Fig. 5, consists in attaching an optical system entirely to the stalk on the eye. In Fig. 5 we show a small crystal polaroid interferometer which produces the ordinary ring brush pattern at infinity. Another method, which attaches the whole system to the eye, consists in mounting on the stalk a small lens and a minute object farther out from the eye. The object is focused by the small lens which yet has a large power. Alternatively the power may be incorporated in the contact lens. This kind of method has been used by the Russian worker Yarbus, who employs a rubber cap instead of the contact lens. These methods in which the whole optical system is rigidly fixed to the contact lens are very satisfactory in maintaining the image on the same part of the retina. However, the type of object which can be displayed is somewhat limited. In particular, it is rather difficult to have a variable bipartite field such as is seen in photometers. It is, therefore, not very convenient to do work on contrast thresholds and similar problems. The apparatus which is shown in Fig. 6 is an optical servo-mechanism. By means of a projector system P a beam of light reflected from the contact lens forms an image of an object at infinity.

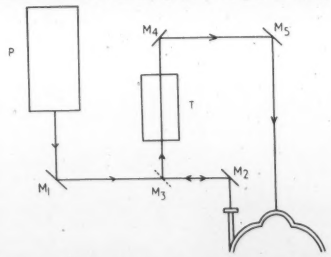

Fig. 6. *Stabilization apparatus. Schematic diagram. The lenses of telescope T are distributed along the path between M_3 and the eye.*

When the eye rotates this beam moves through twice the angle of rotation of the eye. The light is passed through a reflecting telescopic system T whose magnification is a half. The unaccommodated eye then sees, at infinity, an object whose angular movement is exactly the same as that of the eye itself. Since the image is at infinity translational movements of the eye and changes in the centre of rotation of the eye do not matter. The magnification ratio is fixed by properties of the lenses of the optical system and is independent of the eye. Faults in this optical system may be studied with telescopes and the

accuracy with which it achieves a desired stabilization can be studied in detail. It is found possible to arrange the apparatus so that compensation to about one part in a thousand is obtained for both horizontal and vertical movements of the eye.

VISION WITH THE STABILIZED IMAGE

When a subject views the ring and brush system with stabilized vision, the pattern is at first seen perfectly clearly. It then gradually fades, leaving a grey field. After a few seconds the pattern may re-appear less clear than before, only to disappear again. If the subject keeps his eye from blinking the grey field gradually goes darker and finally the light sense itself fails, the field becoming black. This stage is very unpleasant and is terminated sooner or later by a convulsive movement of the eye, after which the pattern is seen very clearly again. We have never been able to hold the black stage for more than about fifteen seconds.

It is also found that other types of discrimination fail. For example the boundary between two colours fades, the shape of a triangular or square patch becomes degenerated, the corners disappear and the subject is left with a diffuse-edged circular patch much smaller in area than the original object (Fig. 2c). When a black bar (Fig. 2b) is displayed on a clear field, the region of the bar appears to be invaded by light, so that the whole field appears bright, that is to say the subject perceives light in a region of the field where the retina can be transmitting no signals to the brain.

If the intermittent loss of visual discrimination is due to the elimination of the on and off signals, we should expect to be able to restore normal vision by flickering the light at a suitable rate. This is found to be so. Flickering at a frequency of a few cycles per second restores nearly normal vision. Another way in which we should be able to restore normal vision would be to impose movements of the retinal image under the control of the experimenter. D. H. Fender and Stella Mayne have made an extended study of the effects of imposed movements. The target used is a black bar on a clear field. A wire which is placed between the poles of a powerful magnet forms the black bar. It can be made to flick or tremor by passing suitable currents through it. A special technique is needed to obtain slow movements of the target without at the same time producing some tremor movements. Even a vibration of a few microns in the apparatus would produce a movement of the retinal image comparable with the natural tremor. Fender has devised the following method of obtaining slow movements uncontaminated with high frequency motion. A motor alters the pressure in a flexible bellows and this pressure is transmitted through a long plastic tube to another bellows attached to one of the mirrors of the optical system. In this way a slow movement can be transmitted while vibrations due to the motor are completely damped out in the transmission system. With this apparatus it is found that slow movements by themselves do rather little to restore vision, but rapid flick movements or oscillatory movements of the same order of magnitude as the natural movements have a very large effect in restoring vision. The variation of the efficiency of vision with frequency and with amplitude is rather complicated and cannot be considered in detail here.

The ultimate object of the experiments on the restoration of vision by flick and by imposed movement is to attempt to analyse the visual perception process by creating conditions in which some kinds of perception are possible but not others. If, for example, it were found that under some régime of movements it was possible to perceive form but not to perceive colour then we should have established something of considerable interest in relation to colour vision. A certain amount of information of this type has been obtained but it is not easy to explain it in a simple and straightforward way. We have to recognize that we are dealing with an exceedingly complicated system and that many elaborate experiments are needed to contribute even a little to its understanding.

The experiments which I have described so far are all fairly well explicable in terms of an "on and off" response. There are, however, a number of results which are not so easily understood. When a subject views a stabilized image he can attempt to fix his attention upon one part of it. It is found that he is able to see more in that part of the field than he can if he fixes his attention somewhere else. Now in normal vision when we fix our attention on one part of a picture, we turn our eye so that the part in which we are interested falls on the best part of our retina, but in the stabilized situation the subject has no control over the relation between his retina and the image. The fact that he can affect vision under these circumstances means that by conscious mental effort he can alter the amount of information received along certain pathways from the retina. Whether this is done by impulses sent from the brain down to the retina in order to super-sensitize a certain region, or to clear the pathways connecting a certain region to the brain we do not know, but clearly there is some effect here which although explicable in terms of rather complicated physiological mechanism, does not fit in an obvious way into a very simple physical theory.

It has long been known that when a person is at the threshold of vision with an extremely faint light there is some effect of quietness or sound, but this has always been regarded as a marginal result whose existence could only be proved by very detailed and lengthy experiments. With the stabilized image a very much larger interaction with sound stimulation is obtained. R. M. Pritchard has found, for example, that under a certain condition the subject can see the target about 10 per cent of the time when everything is extremely quiet. When, however, a sound of 70 dB at 1000 c/s is imposed, the subject can see the target 70 per cent of the time. Several experiments of this type have been carried out and the results are similar to those obtained in certain experiments which physiologists have carried out on animals with electrodes implanted in the brain. These experiments are interpreted in relation to a part of the brain (called the reticular formation) which controls "awareness." If this control is prevented from functioning, either by the use of drugs or by operation, then the animal acts as if it were completely asleep however strong the stimulus of one of the end organs may be.

It appears probable that in normal vision part of the signal transmitted by the nerves from the retina goes to the visual cortex and part to this " centre of awareness," which then sends down signals which improve vision. It seems probable that with the stabilized image some signals are still able to get through to the visual cortex but that the " awareness " is not stimulated in an efficient way. In this circumstance stimulation of the awareness centre by sound has a very large effect.

It thus appears that the simple model of the visual perception system shown in Fig. 1b is far too simple. We need to add a sensitivity adjustment circuit which is controlled primarily by visual stimuli but which can be affected by sound stimuli and also by a conscious mental decision that a scene (or part of a scene) is of interest. A little consideration shows that the simplest control of this kind would be highly unstable and would oscillate wildly. Something further is needed to damp oscillations of this control. One way and another our physical model is becoming rather complicated—but after all this is what we must expect. Human brains are more complicated than computers and the models to describe their detailed behaviour must correspond in complexity.

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* Translation from the Russian Journal *Biofizika*.

Notes and News

As others see us

PRACTICAL ELEGANCE

SCIENCE IN BELGRAVIA

Number 47 is as gracious as the other houses in Belgrave Square. Inside, the well proportioned rooms painted in Adam colours confirm the immediate impression of taste and elegance. But the notice on the outer door gives the visitor an emphatic indication that he is not entering an embassy or literary centre. " During normal working hours," it says, " the lock of the front door is operated by remote control." For number 47 is the Institute of Physics.

(*From "The Times Educational Supplement" account of the Education Group Conference*)

Notes for authors

The Institute has recently published a 36-page revised edition of its booklet intended to assist less-experienced authors and to serve as a reference booklet for all those who wish to contribute to the Institute's publications. Under a new title *Notes for authors* it gives hints on the preparation of scripts and diagrams, on the layout of mathematics, the correction of proofs and so on. In addition to a bibliography of reference books and works on technical writing, the pamphlet also contains lists of the spellings, symbols and abbreviations used by the Institute. These conform with British Standard 1991. Part I : 1954 : *Letter symbols, signs and abbreviations, Part I, General*, which authors of mathematical papers are also advised to consult.

Authors preparing contributions for submission to the Institute's journals are invited to make use of the guidance available in the booklet, copies of which may be obtained from the Institute, price 3s. 6d. (including postage).

International conference on medical electronics

The second international conference on medical electronics will be held in Paris on June 24-27, 1959. Details may be obtained from the conference secretariat, 131 Boulevard Malesherbes, Paris XVIIe.

British Society of Rheology meeting

The British Society of Rheology is seeking contributions on any of the following topics for its Spring Meeting of 1960: theory and measurement of normal stresses; lubrication; effect of impurities on rheological studies; methods and concepts of rheology. Intending authors can obtain further details of the meeting from Dr. M. F. Culpin, A.Inst.P., 8 The Broadway, Pontypool, Mon.

Fourth international conference on ionization phenomena in gases, 1959

The fourth international conference on ionization phenomena in gases will be held in Uppsala, Sweden, from August 17-21, 1959, and has been arranged by the University of Uppsala in collaboration with the Swedish National Committee for Physics.

The main subjects of the conference are scheduled to be: fundamental processes in gas discharges; high frequency discharges; glow discharges; arc discharges; spark discharges; high temperature plasmas and controlled fusion; instabilities and oscillation in gas discharges; new methods of measurements.

The final application forms should be requested as soon as possible. Inquiries concerning the conference and requests for application forms should be sent to the Secretary General, Dr. Åke Nilsson, Institute of Physics, Uppsala, Sweden.

Branch and Group News

Midland Branch : Visit to the B.T.H. Group Research Laboratory

On Thursday, February 12, thirty-four members of the Midland Branch of the Institute of Physics visited the B.T.H. Group Research Laboratory, Rugby. The party was split into small groups and conducted round the Laboratory. A varied list of items were demonstrated including semiconducting glasses, solid state switching devices, high current pulsing equipment, applications of powder metallurgy and research on gas discharges and cathodes.

The visit concluded with a well-attended talk by Professor F. A. Vick, on " The Field Emission Microscope."

Professor F. A. Vick, Dr. R. E. Bastick and others being shown some experiments on discharge physics by Mr. Cayless (extreme left).

Education Group Conference

This year's Annual Easter Conference of this Group was held in the Institute's House on Thursday and Friday, April 2 and 3. The subject of the Conference was " Teaching science to children up to the age of fifteen."

About 120 applications were received but a limit of 90 was made owing to the size of the lecture room, which was filled to capacity. About half of those attending were non-members of the Institute.

The aim of the Conference was to consider realistically the education of children in secondary schools through the teaching of science, and most of the speakers invited had a practical and up-to-date knowledge and experience of teaching in such schools.

The opening speaker, Mr. W. R. Elliott (*Ministry of Education*), spoke upon the Rôle of Secondary Schools in Science Teaching, although as he stated, a headmaster is more concerned with the rôle of science teaching in his school. He outlined the work that is being done in the primary school, and described the prognostic period for the first few years in a secondary school, and how intense specialization is, or should be, delayed and he pointed out the necessity of science in a liberal education. He divided the pupils of secondary schools into five groups. The first group contained those that left school at fifteen and finished with all formal education. The science taught to this group must consist of a few simple problems in close connection with outside activities. The second group left school at fifteen and proceeded to some form of further education. Here the problem was that of transition. This should be as smooth as possible with no loss of momentum, no chasms and little overlap. He also considered whether or not some form of examination was necessary. The third group stayed on for an extra year—a tendency which is increasing—and sat for the G.C.E. (O) Level. He pointed out that whether we can have an examinational system and a liberal education depends upon the teacher and upon the time allowance. The other two groups were those who left at sixteen and went on to take the G.C.E. Advanced Level in a technical college, and those who stayed on and became scientists. The Conference was not primarily concerned with these two latter groups. An interesting and useful discussion followed the talk. Learning by doing, the place of facts, the uncertainty of science, the numbers of pupils going on to science and the grammar school and the syllabus to cater for the different types of pupil were all discussed.

Dr. Cyril Bibby (*College of S. Mark and S. John*) spoke about the Qualities of a Good Science Teacher. He pointed out that the qualities involved were those of a good scientist and of a good teacher. He considered the place of facts, their general utility to the child and to the adult, and made the very important point that we should consider the utility and trends of science during the next five decades—the lifetime of our pupils. He dealt with selection, education in science as an instrument of culture, how it can provide useful knowledge, the adventure of enquiry, exact observation and exact communication. He made a plea for more attention to the education of the senses, more honesty in thought and the critical examination of all statements.

Mr. N. Clarke and Mr. and Mrs. G. P. Gorman.

In the afternoon, there was a Symposium on the Problems Facing the Teacher in the different types of school.

Mr. F. W. Kaye (*South Craven County Secondary School*), spoke about the problems in the modern school. He

emphasized the variety of these schools, the range of ability of their pupils. He explained that science was taught from a cultural point of view rather than from a vocational, that it was an attitude of mind with a core of essential information. He pointed out the influence of science on English and on other subjects.

Mr. G. P. Gorman (*Woodberry Down Comprehensive School*) spoke about the comprehensive school, and considered that it was neither a necessity nor an educational panacea. It had many disadvantages but he thought that its advantages outweighed these. He gave details of the size and construction of his school, the difficulties of discipline, safety of equipment, lack of laboratory technicians, homework, syllabuses, integration of courses, adaptability and effect upon the teaching staff. He considered this type of school to be in the experimental stage and that we must wait a number of years before judging it to be a failure or success.

Miss M. O. Raven (*Watford Grammar School for Girls*) gave an optimistic picture of improving facilities and staff. She pointed out the keenness of the first year, the difficulty of maintaining that interest in the middle forms, the co-ordination of science and mathematics, the influence of examinations and the problem of textbooks.

Mrs. Mary Holmes talked about the small private school and compared it and its problems with those of the large grammar school. She considered the grammar school to be geared for the university candidate, and that the science course was distasteful and difficult especially for the less able girl. She described how she had aroused the interest of young girls in such practical problems as the wiring up of a doll's house, and how helpful she had found parents and school exhibitions.

Mr. C. D. L. Brereton (*Bottisham Village College*) gave an account of the village college, the range of boys and girls catered for, the bias towards the practical crafts of agriculture and horticulture, how the college endeavoured to stimulate or reawake the interest and curiosity of early childhood. He discussed the main problems of lack of drive, the short duration of the course, the careful explanation of problems which have always been obvious to the teacher and the advantages of the best teacher taking the Intake C Form.

This symposium gave a well balanced and inside story of modern schools.

On Friday morning, the facilities of the Institute's lecture room were strained to the limit by Messrs. Glover and Stephenson.

Mr. A. H. T. Glover (*Educational Film Producer*) gave a superb, humorous and dramatic demonstration of the use of visual aids in the class-room, from the flannel board, through the pin-board to the still and universal ciné projector. In passing he gave many useful teaching hints. He certainly held the attention of his audience throughout, proving his skill as a teacher and as a photographer.

Mr. J. P. Stephenson (*City of London School*) showed how an introductory course in real science could be devised using material such as milk bottle tops and bits and pieces easily obtained by boys, in order to make the required apparatus. It was a convincing demonstration of how the enthusiasm of the teacher and scientist can arouse the excitement of science in the average boy. The boys attending the City of London School are to be envied. Mr. Stephenson critically discussed various elementary science syllabuses. He took various topics from them and discussed how best they could be taught. For teachers of elementary science, his demonstration was an inspiration.

On Friday afternoon, Mr. L. P. Grice (*General Electric Company, Ltd.*) explained the opportunities offered by industry for boys leaving school. These he divided into four categories :—1. Unskilled ; 2. Craft ; 3. Technicians ; and 4. Professional. He showed how rapidly the need for unskilled has dropped over the last four

Dr. L. E. Lawley and Dr. R. F. Y. Randall.

years, to less than half. He said that such were put to work straight upon the job. His second category were employed for their manual skill and were generally given a five year training course, with day release to attend the local technical college, for C. & G. or N.C. courses. He referred to the enormous wastage in these courses and considered it to be mainly due to bad direction. The third category were skilled manually but had also a certain amount of technical "know-how." Amongst these were draughtsmen and laboratory assistants. He dealt with the standards of entry and courses to be followed. The fourth category—the professional—stayed at school until eighteen and were therefore not considered. Further points considered by Mr. Grice were the transition from school to industry, methods of selection and the effect of the bulge.

The final speaker was Mr. N. Clarke (*Institute of Physics*) who considered a parent's point of view. He stated that education was too important a subject to be left to the educationist and that parents should take their share in deciding educational policy. This had been enacted but not implemented. He made a strong plea for treating the child as a complete person, to educate

the child for life in the world in which he is going to live and to build the foundation upon which value judgements may be formed. He considered the child should be educated for the exercise of adult responsibility. He dealt with the co-operation between parent and school, the quality of the teacher, science as a liberal subject and the snobbery about the secondary modern school.

Altogether, it was a most interesting and useful conference, and those teachers who attended went away with much to think over and to use in their own teaching. A number of the papers read will in due course appear in this *Bulletin*.

T. H. TYLER.

Correspondence

Electrodynamics

Dr. Builder, in the *Bulletin* of December last, refers to me as having attempted " to revive and promulgate the Ritz and Ampère formulae," saying that the former is only derivable on the hypothesis that all electromagnetic effects are emitted ballistically, and that this is incompatible " with the overwhelming evidence that the velocity of light is independent of the motion of its source." This is very far from the case.

My theory is one of retarded action-at-a-distance; on such a theory there is no ballistic or medium transmission and no conflict with the evidence that the velocity of light is independent of the motion of source and receiver (although I believe it, I do not agree that this evidence is " overwhelming " and have suggested the repetition of Majorana's experiments).

I derive the interparticle force-formula from the results of experiment, assuming that in neutral conductors carrying currents there are moving charged particles. The measured forces between circuits carrying steady currents give the velocity terms, and forces in radio oscillators yield the acceleration terms. Ampères formula as generalized by Maxwell is used for the velocity terms and the results of radio experiments for the acceleration terms. This is an entirely different derivation from that of Ritz. The formulae may be similar but Dr. Builder is not correct in saying that the derivation can only be on the ballistic hypothesis. The same formula may be arrived at by different treatments. This fact invalidates his argument about the untenability of Ampère's formula.

The statement of Ritz's formula on p. 312 does not seem to be correct : this formula contained a constant, and did not represent a force acting in the line joining the two charges except for one particular value of this constant, and in the absence of acceleration. I do not remember that Ritz ever settled the value of this constant.

Those interested will find my theory more fully explained in " The Unification of Macroscopic Physics," *Science Progress*, **181**, (1958) p. 15.

G. BURNISTON BROWN.

University College, London, W.C.1.

Graduateship Examination

As a physicist in industry with some responsibility for advising young people regarding suitable training in physics, I am much disturbed by the comments expressed by Prof. Lipson in the February, 1959, *Bulletin*. If I read these comments correctly, it would appear that the More Advanced Physics Paper in the Graduateship examination could be subtitled " Beat the Examiner " ! For any candidate to get very good marks he must, in any four out of seven questions set by Professor Lipson, give replies which contain more than the examiner can judge and which need to be checked against the textbooks.

If last year's paper is any guide, I contend that there are few of the questions set for which this step would be necessary (surely, none of the answers to Questions 1, 2, 3, and 7 would send Professor Lipson rushing for his textbooks). In this paper then, however well a candidate answered his four selected questions, he could not earn very good marks for all of them and, if he was unfortunate enough to select all of the questions listed above, he could, at the very best, only earn reasonably good marks.

Professor Lipson's comments mean that, in future, candidates will at least know the sort of question they must answer to be able to earn very good marks. But I wonder how much encouragement the comments will give to those potential applicants for membership of the Institute, whose route thereto lies via a Graduateship examination in which " More Advanced Physics " is an unavoidable paper ? How many of the present members (myself included) could satisfy the examiner's exacting demands ?

Surely, the standard of any part of the Graduateship examination was never meant to be such that the earning of very good marks could be achieved only by forcing the examiner to consult textbooks for every answer.

Having seen the standard of marking set by this examiner it would, undoubtedly, help candidates and teachers alike if we could have the comments of the other examiners on the standards to which they mark these papers. Is this " Beat the Examiner " system widespread and, if so, how many, like Professor Lipson, are still unbeaten ?

In recent years I have tended to advise junior employees to pursue a course in applied physics leading to a diploma and thence to the Graduateship examination, but I am now left wondering whether the chances of ultimate success in this " Beat the Examiner " type of examination are not considerably less than those of gaining a university degree by part-time study.

J. NORBURY (*Fellow*).

Central Research Laboratories,
Richard Thomas and Baldwins Ltd.,
Whitchurch, Aylesbury, Bucks.

Professor Lipson comments:

On re-reading my contribution to the February *Bulletin* I can see that it can be misinterpreted. What I should have said is that I have no compunction in

setting *some* questions on subjects of which I have no expert knowledge and in then judging the candidates' abilities relative to my own. I should have thought that candidates would be encouraged by knowing that there are questions of this type ; there must be nothing more discouraging than being examined only by experts, to whom one's most profound thoughts may appear always trivial.

Dr. Norbury flatters me slightly. The derivation of the expression for Compton scattering is a complicated business and I doubt whether I could have done anything like so well as several candidates under examination conditions ; but I could have bettered them all on the experimental work. On the determination of the structure of copper I could (I hope) have gained full marks ; I would have given full marks for much *less* than I myself would have written.

But I am particularly disturbed at the suggestion that my comments may discourage students. My intention was quite the opposite. I wanted candidates to realize that they should enter the examination room with the question " What do I know ? " rather than " What does the examiner want ? " I try to devise questions that give some scope for self-expression ; candidates must not think that there is always a set answer, and that if they do not know it they are doomed !

Finally, I would point out that candidates do not need " reasonably good marks " in order to pass ; the pass standard I would describe as " fairly low." The reasonably good mark would indicate the exceptionally good candidate and anything above would indicate the first-class mind that we are all looking for—in universities and outside !

The interpretation of relativity

In the correspondence columns of the February *Bulletin* Professor Dingle, says the " arrival of the light at any point . . . is an *event*. Its time and place may be estimated differently by different observers, but its *space-time location* is *absolute*."

It has always appeared to me that the essence of the Theory of Relativity is the admission that " the absolute" is inascertainable to our senses and hence cannot be assumed as a valid basis of argument about space-time relationship as we know, or can know them. I am not either a mathematical physicist, nor a metaphysician, so I should be glad to have my mistake cleared up !

J. J. Dowling (*Fellow*).

2 Garville Avenue,
Rathgar, Dublin.

From industry to technical education

It is apparent from various discourses on the future of technical education that it is essential to encourage the transfer of the right type of person from industry to teaching. This was re-iterated by Dr. Crank (*Bulletin*, Vol. 10, p. 32). I agree with most of the author's observations and especially, that junior lecturing grades are not sufficiently attractive to the right man. However, there are some aspects with which I must disagree.

An industrial man may be attracted by less holiday and more pay, but I doubt whether these conditions would be sufficient to retain a person who would be mainly concerned with financial rewards. I do not think that salary scales alone are the determining factors.

To say that members of staff of a college are present in the main for only three-quarters of the year, is misleading. In expanding colleges members of staff are involved during the summer in organizing new courses, student projects, etc. The right type of man is the one who is prepared to do this. Does Dr. Crank suggest that men from industry would need extra payment for such duties ? If the lecturing and allied duties are undertaken conscientiously then a proportion of research by staff must of necessity by carried out when students are absent.

In my opinion, lecturing cannot be assessed on " so called teaching hours." An advanced lecture of one hour requires considerable preparation. This is particularly so for new courses and in an "enlightened college " there will be a proportion of these, including postgraduate courses, each year. Some of this preparation has to be done at home, since experimental research and certain administrative duties can only be done at the college. Laboratory and tutorial work has to be corrected outside contact hours. Dr. Crank quotes contact hours which I do not consider to be representative. A more realistic value for a Grade B would be 18-20 hours. I think it is most unwise to make a comparison with university conditions unless facts can be given.

A prospective candidate from industry must consider the prospects. How many can be attracted by the prospect of heavy lecture preparation especially in the first two sessions unless he has an interest above all others to lecture ?

A keen candidate may not wish to gain financially. On the other hand he should not be expected to lose by the transfer. Apart from such factors as working conditions, travel facilities, exchanges with industry, time and equipment available for research to make posts more attractive, it is felt that the following points ought to be considered :—

1. Light duties for at least one term to allow time for lecture preparation.
2. Lecturing should be offered as a career and this would mean that a man appointed as an assistant should have ample opportunities to reach at least the senior lecturer grade. To do this assistance could be given towards removal of family and effects as by many firms.
3. Temporary rented accommodation should be available so that a person who has to sell property has somewhere to live whilst seeking a new house in a strange area.

At present some younger members of staff cannot afford a move in order to gain experience. Internal promotion is possible, but in many colleges is rather the exception than the rule.

In conclusion, I would hasten to add that I transferred from industry over four years ago and have had no occasion to regret the transfer.

W. E. J. Neal (*Associate*).

College of Technology,
Birmingham.

Reviews of Books

LIQUID HELIUM

By K. R. Atkins

London : Cambridge University Press. Pp. x + 312. Price 60s.

The strange properties of liquid helium are forming one of the most fascinating problems in modern physics. Almost twenty years have passed since W. H. Keesom's great classic on helium was written. At that time only the first data on the anomalous transport effects were available and little work had been done on the theory. Since then, not only have new phenomena been discovered and new theoretical approaches been found, but sufficient quantities of the light isotope (with weight 3) have been produced in nuclear reactions to permit liquefaction and study of this liquid. A new book, presenting our present state of knowledge, will therefore meet with general welcome. However, to write such a book is no mean task and it is fortunate that Professor Atkins, who himself has actively worked in the field for many years, has now undertaken it.

With any subject there comes the time when it passes from the stage of an imperfectly understood curiosity into that of a well established body of knowledge. The change is indicated by the approach of the textbook writers who treat the theory as an appendix when the subject is still in a state of flux but start with the theory when they feel it is accepted. Professor Atkins has evidently decided that liquid helium has passed into the established stage and this is the only aspect of his book on which one might disagree with him. He starts with a short introduction of the basic phenomena, then sets out the theory from which he develops in a number of chapters the thermodynamic and hydrodynamic consequences, together with a discussion of the experimental material. In this way he introduces a systematic approach into a largely amorphous body of fact which by now has grown to such proportions that even the experts are apt to overlook material which is relevant to their own work. He also is able to show up the gaps in the existing data and to indicate fields of future research. An unavoidable disadvantage of this treatment is that information on any particular phenomenon may be spread over three different chapters, which makes quick reference difficult and cumbersome.

Professor Atkins has made a judicious choice of examples from the great number of, often parallel, investigations in order to illustrate his account of the properties of the liquid and he has done justice to the rest of the research by providing an exhaustive bibliography, containing references to almost every paper published. Two final chapters deal with the properties of liquid ^3He and of $^3He - ^4He$ mixtures. The book can be warmly recommended not only to those working in the field, for whom it will be indispensable, but to many others who are interested in the helium problem. It is to be regretted that the price will put it out of reach for most students.

K. A. G. Mendelssohn.

PRINCIPLES OF MODERN PHYSICS

By A. P. French

New York : John Wiley and Sons, Inc. ; London : Chapman and Hall, Ltd. Pp. ix + 355. Price 54s.

This is a very useful book indeed. If one compares it with two widely used texts, Slater's *Modern Physics* and Born's *Atomic Physics*, this book is more advanced and comprehensive than Slater's, less so than Born's. The discussion of relativity, for example, is exceptionally clear, and there is a coherence of treatment throughout, which Born's *Atomic Physics* has rather lost with its expansion through successive editions.

The subject-matter develops from classical kinetic and electromagnetic theory, through ions and quanta, to wave-mechanics and its simpler applications to e.g. atomic spectra and the specific heat of solids. The book ends with a substantial chapter on nuclear physics.

Through dilatoriness in reviewing it, I have already given the book a partial trial as a teaching text and consider it particularly good as a revision book for final year physics students. It contains a good deal less than we should expect such students to have read, but very little less than we can reasonably expect them to be able to work out. There is a good supply of problems, many of the harder ones generalizing results which are proved for simple instances in the text. Several appendices deal with, not very difficult, but extensive proofs which are passed over, to obtain cogency of argument, in the text.

The bibliography has many good things with some rather odd ones : statistical mechanics, to judge from the books he gives as references on it, is not one of the author's fields of interest. In most respects, though, the bibliography is extensive and well chosen.

If this book were taken as the start of a " modern physics " course, one would wish to add a good book on the states of matter (usually wrongly described as solid state physics) and one on nuclear and subnuclear particle physics. Unfortunately, most writers on nuclear physics begin with a scrappy account of atomic physics, before starting to give the reader his money's worth : many writers on chemical physics make the same error. However, the fact that much similar material will be repeated elsewhere does little to diminish the advantage of having so much of it so clearly done here.

I have no hesitation in recommending this book.

G. A. P. Wyllie.

PLANNING OF EXPERIMENTS

By D. R. Cox

London: Chapman and Hall Ltd. Pp. vii + 308. Price 60s.

The laboratory worker who seeks to demonstrate an effect must estimate the precision of his observations in order to provide a background for the assessment of the significance of any difference he observes. There is no

reason why, with proper planning, each experiment should not provide its own estimate of this precision. The power to do this is all the more important when the experiment must be carried out on material or in conditions which themselves contribute to the imperfect precision. The practice so often adopted of compounding estimates of error for the various stages obtained from other experience subtracts an important element from an experiment, one which can validate or invalidate the conclusions.

Most of the work that has been done on experiment design is statistical. Here is a book which discusses the problem from the experimenter's point of view, and not only the field and factory experimenter but the laboratory worker as well. There are many features of design which receive scant attention in the statistical texts (the need for and nature of randomization is one) particularly those which are implicit in the underlying theory. Here not only the need but the practical realization of these features is discussed at length.

A valuable feature is the number of case histories interpolated in the main text in smaller type. The fact that only a few of these are directly from the field of laboratory physics results not from a lack of applicability of the ideas but because not enough physicists apply them. The author is not only a leading statistician but has considerable experience as a consultant in many fields of scientific experiment and in this book he shares that experience. The book does not replace the statistical text, it is intended to supplement it; yet it can usefully be read on its own. It will appeal both to those with a knowledge of statistics and those without.

E. D. VAN REST.

ELASTICITY AND PLASTICITY

By J. Goodier and P. Hodge.

London: Chapman and Hall Ltd. Pp. ix+152. Price 50s.

This book is in two separate parts; the section on elasticity has been written by Professor Goodier and that on plasticity by Professor Hodge. Their styles, approaches and attacks are quite different.

Professor Goodier's is a single chapter of some 40 pages divided into thirteen articles or sections, consecutive articles running on though not necessarily having any connection. The reader, I feel, would welcome the warning of a break of page or even an intervening chapter heading to condition him for some of these abrupt changes. The author's principal aim is " to draw attention to those significant recent developments believed least known to readers whose first language is English." The result is something which, as the author acknowledges is neither proportioned nor exhaustive. It will be very useful to those with a developing interest in elasticity but I am doubtful whether there is enough background to give it value to the wider mathematically literate audience at which it is aimed. In fact this criticism stems rather from measuring the book against the standards set in the Preface than from the material itself. There have been extremely valuable Russian contributions particularly on mixed boundary value problems and the importance of Professor Goodier's articles in making these readily available cannot be overstressed.

Professor Hodge's task was perhaps an easier one in that he covers a subject with a more limited front, measured in terms of achievements to date. His contribution of some 100 pages is conventional in layout and comprises seven chapters. The first four are concerned with the general theory, the next two with specific applications and the last with Russian contributions. The emphasis here, as in the whole of the series, is on the mathematics of the subject but whilst Bers in Vol. III could argue with some justification that the physical and experimental sides of his subject were already adequately covered elsewhere in the literature I am not sure that the same can be said here. Indeed it does force one to express doubts about the wisdom in general of divorcing the mathematics and physics as completely as is done here. However within that limitation it provides a very useful account of the subject.

L. HOWARTH.

CHAMBERS'S TECHNICAL DICTIONARY (Revised edition)

Edinburgh: W. and R. Chambers Ltd. Pp. 1028. Price 35s.

This useful dictionary containing some 60,000 terms was first published in 1940 and has been revised and reissued with supplements several times since then. The present (third) edition has been " heavily revised " and the " greatly enlarged supplement contains a wealth of new terms relating to the latest advances in science and technology." English speaking scientists, engineers and indeed " all those who wish to understand what they have to say to each other " have for the last 18 years been indebted to the compilers of this valuable work and will continue to be so long as they go on keeping it up-to-date in these days of rapid progress. Tables in the field of chemistry, geology, botany and zoology are included. A helpful feature is the inclusion of an observation after each term showing to which branch of science or engineering the term relates; although some might disagree with the classifications given, especially as the boundaries between subjects are so very uncertain. The noble attempt to distinguish trade names accurately when so many have almost become, if not have actually reached, the status of generic terms, will be appreciated by all technical writers and editors. In such a work it is not difficult to find points with which one might disagree, and as the Editors explain in their preface, many of these are matters of opinion on which experts differ. Rightly they have chosen to use the forms and definitions preferred by those who are actively engaged in the practice and teaching of their respective subjects rather than any more academic and pedantic definitions.

The production and format is adequate for the comparatively low price of such a valuable work, but there might be a sale for a de luxe edition.

H. R. LANG.

PROGRAMMING FOR AN AUTOMATIC DIGITAL CALCULATOR

By K. H. V. Booth

London: Butterworths Scientific Publications. Pp. vii + 238. Price 42s.

This is essentially a guide to the operation of a particular machine, that in use at Birkbeck College. The author obviously has no intention other than to explain the operation of the basic programmes used with APEXC, and this she accomplishes with skill. The dichotomy of the programming process into a schematic system independent of instruction position, followed later by insertion of appropriate addresses (described in Chapter 2) is, of course, not peculiar to two address machines and has long been practised for other machines by experienced programmers, particularly where more than one level of storage is employed; but I believe this is the first time it has been made explicit in print. Apart from its intrinsic interest, the decision to include a chapter on mechanical translation, whilst omitting any form of process suitable for step by step integration, any discussion of partial differential equations, and any reference to X-ray Crystallography (for which work, one assumes from its name, the machine was designed) seems open to question. However, the book is certainly of great interest to programmers right down to the provocative last section on automatic programming. But it is too detailed for the general reader and truly appropriate only for those who intend to operate machines similar to APEXC.

A. S. Douglas.

STATISTICAL THEORY OF IRREVERSIBLE PROCESSES

By R. Eisenschitz

London : Clarendon Press : Oxford University Press. Pp. viii + 83. Price 8s. 6d.

The theory of matter in thermal equilibrium was given its final form by Willard Gibbs in 1901. The theory of the approach to thermal equilibrium is, however, as yet far from completion. Nevertheless, much work has been done in recent years, and the point is approached at which a unified theory of irreversibility appears to be within reach.

So far, however, these developments are hardly known outside the ranks of the specialists, and it is the main purpose of this monograph, which is the third of the Oxford Library of the Physical Sciences, to present the subject to the wider public of research workers in physics, who have a basic knowledge of atomic physics, quantum theory, and elementary statistical mechanics.

Starting from the classical mechanics of particles and classical equilibrium theory it goes on to consider viscosity and thermal conductivity of gases and liquids, statistical quantum mechanics, and its application to gases and to the solid state.

Though forming a stimulating review of the subject from the point of view of the specialist, to achieve its expressed purpose this book could with advantage be expanded considerably to allow fuller explanation of the steps by which the various results are developed. The final chapter on probability is rather trivial in relation to the concepts of distribution functions, singlet and doublet distribution, and so on, which are taken almost for granted in the main text.

A. W. Gillies.

MATHEMATICAL ASPECTS OF SUBSONIC AND TRANSONIC GAS DYNAMICS

By Lipman Bers

London : Chapman and Hall Ltd. Pp. xv + 164. Price 62s.

In the preface to this, the third volume in Surveys in Applied Mathematics, F. J. Weyl the Director of the Mathematical Sciences Division of the Office of Naval Research gives broadly speaking two aims as the basis for the series. These are (i) the need to make readily available up-to-date results in selected areas of research and (ii) the need to relate contributions from both sides of the iron curtain in order to produce a balanced appreciation of the present state of knowledge in any such area. In elaborating (i) he goes on to say that the present articles are " therefore aimed not so much at research specialists, actively contributing to the subjects discussed, as they are aimed at a broader, mathematically literate audience . . ."

Certainly the author of the volume under review demands mathematical literacy of his readers. He is at pains to point out that his emphasis is on the mathematical methods, and on existence and uniqueness theorems rather than on the physical problems themselves and that his book does not in consequence overlap seriously with existing literature on subsonic and transonic flows.

The physical behaviour of subsonic flows is reasonably well understood and the time is ripe for a consolidation of their mathematical basis. Not unnaturally the non-linearity of the equations raises many interesting and difficult problems and treatment in the present book brings out the way mathematical techniques have been and are being extended to cope with them.

When we come to transonic flow the situation is rather different. The mixed elliptic-hyperbolic nature of the governing equations has led to both physical and mathematical difficulties tending to converge on the same points, as for instance in the question of smooth transonic flow and the effects of small profile variations. Here I think it fair to say that one can't expect more than a progress report and that is what is presented, albeit an encouraging one.

Within the limited scope set by the author's aims the book measures up to its task in an eminently satisfactory way. One can but share the author's evident regrets at time spent—more than two years—in press, but the very extensive and welcome bibliography has been somewhat extended to cover these two years.

L. Howarth.

THE POTENTIAL THEORY OF UNSTEADY SUPERSONIC FLOW

By J. W. Miles

London : Cambridge University Press. Pp. xii + 220. Price 45s.

The editors of the Cambridge Monographs on Mechanics and Applied Mathematics are to be congratulated on adding Professor Miles's name to their collection

of distinguished authors. The result is a most welcome book on unsteady supersonic flow. The treatment is individualistic, as those who know the author might expect, but at the same time it provides a comprehensive survey of the subject as it was at the time of writing in 1957.

The book is almost entirely concerned with the linearized equations of supersonic flow and chapter 1 contains their derivation together with a discussion of when further simplifications can properly be introduced. This is accompanied by a very useful chart showing what parametric restrictions are imposed by the various simplifications. The method of presentation adopted is to use a modified Lorentz transformation to simplify the boundary problem at the expense of having a " hyperbolic " wave equation and then to apply integral transforms (both Fourier and Laplace) for developing solutions. Professor Miles claims that this achieves a high degree of formal uniformity and compactness of analysis and on the results I think he is justified in making this claim. He does, moreover, draw the attention of the reader to other possible approaches.

The pattern followed by the book is then to discuss the known exact solutions of the complete linearized equations and subsequently to proceed to the more general planforms requiring additional approximation.

As might be expected the bulk of the book is devoted to wing problems but the penultimate chapter gives a useful account of results for slender bodies and wing-body combinations. Apart from the general discussion in Chapter 1 the discussion of non-linear effects is confined to the final chapter which deals with second-order wing theory, the two-dimensional slowly oscillating aerofoil and Lighthill's hypersonic approximation.

Not least among the book's virtues is its extensive bibliography.

L. Howarth.

HANDBOOK OF THE ATOMIC ENERGY INDUSTRY

By Consulting Editor : Sidney Jefferson

London : George Newnes Ltd. Pp. vii + 270. Price 35s.

The word " handbook " has come to mean a comprehensive volume containing all the data which a professional worker in the subject is likely to require. The book under review is not a handbook in that sense, but would be more correctly described as a summary for non-specialists interested in some aspect of the atomic energy industry.

The book consists of the following nineteen sections, written by twelve contributors :—" Atomic Energy Authorities Throughout the World " ; " Education and Training within the Atomic Energy Authority " ; " Development of Nuclear Energy " ; " Atomic Structure " ; " Nuclear Fuels " ; " Nuclear Reactors " ; " Nuclear Power for Aircraft " ; " Nuclear Power for Marine Propulsion " ; " Basic Reactor Physics " ; " Metals of Interest in Atomic Energy " ; " Moderator and Reflector Materials " ; " Nuclear Research Machines " ; " Radioisotopes " ; " The Use of Radioisotopes and their Radiations in Industry " ; " Medical, Biological and Agricultural Uses of Radiation and Radioactive Isotopes " ; " Radiation Hazards and Protection " ; " Radiation Detectors " ; " The Handling of Radioactive Isotopes " ; " Radioactive Waste Disposal."

The standard of the sections is rather uneven. The longer ones, such as those on Nuclear Fuels and Reactor Physics, are good, but some of the others are too short to be effective. The book could have been improved by better co-ordination between the sections, by combining some of the very short sections, and by avoiding overlapping.

For example, in Section 3, temperatures of over five million degrees have been attained in Zeta, but in Section 8, a temperature of six million degrees has been reached ; both statements need qualification. The capacity of the Hinkley Point station is stated to be 300 MW in Table I (Section 6), and 500 MW in Table 5; the latter figure is correct. The equation for exponential decay is explained in Section 13, and again in Section 14, and the unit of cross-section is defined twice, although the word " barn " does not appear in the index.

Very few references to other sources of information are given, and the usefulness of the book would have been increased by a carefully-selected Bibliography.

The biological effects of radiation are of universal interest, and in Section 15, it is shown that mammals and man can be sterilized or killed by radiation doses only 1/100 or 1/1000 of the corresponding values for arthropods, protozoa, or bacteria. The insects and bacteria have always been formidable adversaries in the struggle for existence, and if mankind persists in producing uncontrolled radiation in increasing quantities, there seems to be no doubt as to the forms of life which will inherit the earth.

J. S. Forrest.

EXAMPLES IN APPLIED MATHEMATICS

By F. W. Kellaway

Glasgow : Messrs. Blackie & Son Ltd. Pp. vi + 127. Price 7s. 6d.

This is an excellent little book of examples in Applied Mathematics, by which is implied Statics, Dynamics and Hydrostatics. The level is that of the examinations for Advanced Level General Certificates, for Ordinary National Certificates and the Intermediate B.Sc. in Engineering.

In preparing the second edition, the author has taken the opportunity to remove some over-formal questions and to add others more in keeping with modern requirements. Over 500 examples are now available, with answers.

The book is attractively set out and the diagrams are clearly drawn and labelled. It can be recommended as a source of a good variety of problems. Many of them are originals and others are taken from various examination papers.

J. Crank.

JUNCTION TRANSISTOR ELECTRONICS

By Richard B. Hurley

London : Chapman and Hall Ltd. Pp. xvii + 473. Price 100s.

The first chapter is aptly entitled " Low Level Semiconductor Physics " and again one is struck by the disparity between the wealth of excellent books on transistor circuit applications and the paucity of comprehensive works dealing with solid state theory from an elementary to an advanced (Final Honours) standard. It cannot be satisfactory for undergraduates to be confronted repeatedly with formulae whose derivation is so obscure. Admittedly the proper explanation of transistor action is much more difficult to provide than in the case of thermionic vacuum triodes, for example. Experts and intending authors please note. In the present work the circuit theory is presented carefully and in great detail and for this purpose the book can certainly be recommended. There are further chapters on diode and tetrode analysis, gain and impedance formulae, a.f. amplifiers, transistor noise, degenerative feedback, high level physical considerations, power d.c. video and frequency selective amplifiers, d.c. regulators, h.f. equivalent circuits, internal feedback compensation, gain control, sinusoidal oscillators, modulation, switching theory, non-regenerative and regenerative switching circuits and finally transistor saturable reactor circuits.

The technical style of the book, printing and binding, etc., are of a very high standard.

J. D. Craggs.

BASIC ELECTRICITY (5 parts)

By Van Valkenburg, Nooger and Neville

London : The Technical Press Ltd. Price 12s. 6d. per part, 55s. the set.

Originally devised for training technicians in the United States Navy, and adapted to British needs by a R.E.M.E. team from Arborfield, this has been adopted as the basic training text by R.E.M.E. It should be highly successful for this purpose, and will also arouse a good deal of interest among teachers of physics generally. The chief features are its simple language, clarity of presentation, and the use of diagrams as a substitute for description in building up the concepts in the early stages. Working backwards through the book, parts 3, 4, and 5, on alternating current with its associated circuitry and electrical machines, are excellently done ; and the authors have made very skilful use of graphical methods to circumvent mathematics as such. These are reinforced by a number of excellent quantitative experiments, and the reader working through the course on his own could, for an outlay of the order of £30 on apparatus, get full benefit from these. Being a little unsympathetic myself towards the personality cult that started with Thomas the Tank Engine and reached its finest flowering with Mr. Cube and Mr. Therm, I did wonder whether the first part was really helped by pictures of electrons trotting round with smiles on their faces ; but the authors must have satisfied themselves that people thrive on such an approach. Indeed, it may be that they have laid a finger on one of the weaknesses of the usual method of teaching electricity, where one does assume rather too readily that the pupil appreciates what is happening simply because one has shown him some meter readings. I would say, too, that the first two parts are aimed at students with a lower level of general education than the usual run of potential electricians ; and this cartoon-drawing illustration may well succeed where other methods fail. It would be interesting to know, after the course has been in use for some time, whether the excellent physics of the last three parts, or the very pictorial approach of the first two parts, is the major factor contributing to its success.

G. R. Noakes.

PHYSICS IS EASY

By D. S. Watt

London : Princes Press Ltd. Pp. 550. Price 63s.

It would surely give the author and the publishers the surprise of their lives if this book were to be recommended to readers of the *Bulletin*. For the publisher's encomium says " You are probably a born physicist and nuclear scientist but don't know it. Read this book and find out. A little training and guidance will put you right." Discounting this rather ridiculous blurb, one can try to assess its possible value as an attempt to establish a rigorous sector on the popular front.

There are some commendable features. The author knows his mechanics well, and makes a genuine attempt to take a reasonably intelligent beginner through the exacting first stages of the subject. For the rest, the treatment is rather slender ; and I would not prefer it to any of the dozen or so good Ordinary-level textbooks that there are about. It has a certain air of the writing-desk as opposed to the laboratory or lecture-bench ; and is written in a conversational style which has too high a ratio of exhortation to explanation. The idea behind the book is excellent ; that, if you are going to try to find out something about physics, you must master the fundamental groundwork properly first. I doubt very much whether the kind of reader who is prepared to work so hard would be attracted at all by this kind of book. But I may be quite wrong about this. Physics is not easy, even to write about ; and it is possible for a reviewer who knows that it isn't to misjudge an author who represents that it is.

G. R. Noakes.

The Institute's Journals

PRINCIPAL CONTENTS OF THE MAY, 1959, ISSUES

The price of the annual volume (twelve parts) of each journal is £6 to non-members and £1 10s. to members of the Institute.

Journal of Scientific Instruments : Volume 36, No. 5

SPECIAL ARTICLE

The Physical Society's Exhibition—London, 1959. By R. V. Jones, F.Inst.P.

A general survey is given of the newer developments of instruments and apparatus exhibited, together with some observations on the Exhibition and the prize list of the craftsmanship and draughtsmanship competition.

ORIGINAL CONTRIBUTIONS

Quick-acting chemical balance. By B. O. Smith, A.Inst.P., and J. W. Stevens.

The balance described is particularly well suited for use in an analytical laboratory in which repetitive weighings are made to an accuracy of one part in 5000. It is characterized by rapidity of operation, and robustness of suspension. Its regular use should enable substantial savings in time and labour to be made. The beam is balanced by an electronic servo system with a fast response speed and excellent long-term reliability.

Geiger counter hodoscope with automatic testing. By H. S. Murdoch and H. D. Rathgeber.

A multi-channel Geiger counter hodoscope is described which records automatically on punch cards, uses a simple but effective quenching circuit and contains a testing circuit. An automatic hourly test is applied to all channels, providing a random sample of their behaviour and enabling speedy detection of faults either in the counters themselves or the associated recording circuits.

Monitored Geiger counter X-ray diffractometer with automatic recording. By E. R. Pike, A.Inst.P., and J. W. Hughes, F.Inst.P.

The equipment produces automatically a compact photographic record of a step-scan of a powder diffraction pattern in steps of 0·02° (2θ). It is arranged that movement over the background region between lines is rapid, so that only the line profile and the immediate background on either side are recorded in detail. The specialized electronic circuits and the relay-operated automatic sequence control circuits are described, together with a special automatic camera provided with various safety devices to protect the record. Facilities for other scanning procedures are also provided.

Galvanometer feedback systems. By J. A. Sirs.

The principles of applying feedback to a galvanometer, after optical and electronic amplification, are discussed. In particular, the galvanometer performance is examined when proportional, differential, compound and selective feedback systems are used. The latter method is compared with mechanical and series-capacitor tuning of the galvanometer response.

Interferometer based on four diffraction gratings. By F. J. Weinberg, A.Inst.P., and N. B. Wood, Grad.Inst.P.

An interferometer based on diffraction gratings, used over their whole area, and designed to overcome some of the disadvantages of the four-mirror Mach-Zehnder arrangement is described. Its theoretical and practical assessment leads to the conclusion that, in comparison with the latter, it is remarkably inexpensive and insensitive to misalinement, though wasteful of light and subject to certain residual optical imperfections.

High-resolution nuclear resonance apparatus. By J. B. Leane, R. E. Richards and T. P. Schaefer.

A nuclear resonance spectrometer for observing high-resolution spectra of hydrogen and fluorine resonances is described. The spectrometer is of extremely simple design but its stability and resolving power is approximately 1 in 10^8 when using samples of diameter approximately 5 mm. A thermally-lagged permanent magnet is used to provide the main magnetic field and a simple bridged-T spectrometer is used.

Illuminant for the colorimetry of fluorescent materials. By W. Harrison.

The colorimetry of specimens containing fluorescent whitening agents (optical bleaches) requires an illuminant with adequate ultra-violet content to at least 3600 Å. Single sources based on the filament lamp have, generally, a low ultra-violet content. The use of two sources, one equivalent to Illuminant C provided by a filament lamp screened with an O.B. 8 filter, and the second the same lamp screened with an O.X. 1 or modified O.X. 1 ultra-violet filter, is suggested as giving a satisfactory approximation to the daylight spectral distribution, both in the visible and in the ultra-violet regions.

Automatic correction for paralysis in Geiger counting. By R. Hunt.

A simple and inexpensive attachment to a standard probe and scaler unit is described which provides an automatic correction to the scaler reading in radioactive assays using Geiger counters. Over the usual range of operation of these counters, 0 to 16,000 impulses/min, the relative errors in the scaler reading due to paralysis of the counting system are thus reduced to 0·3%.

Controlled atmosphere levitation system. By B. Harris and A. E. Jenkins.

A levitation system designed to melt and cast small quantities of metals under controlled-atmosphere conditions is described. Temperature control of the levitated sample and certain other practical aspects of the technique are discussed on the basis of experience gained over a two-year development period.

Infra-red absorptiometer, using interference filters, for analysis of hydrogen fluoride in gaseous mixtures. By J. A. Harrison and C. D. Reid.

A wavelength-scanning infra-red absorptiometer using interference filters has been developed for analysis of hydrogen fluoride in corrosive gas mixtures. The wavelength scanning is achieved by tilting an interference filter at 10 c/s, thus passing alternate beams of different wavelength through the same sample tube. Only one of the beams is absorbed by hydrogen fluoride, while the other is used as a reference beam; a difference signal depending on the partial pressure of hydrogen fluoride is measured. Using this principle, the instrument has been designed so that the calibration is independent of corrosion of the windows of the absorption tube. The prototype instrument detects partial pressures of hydrogen fluoride in the range 0·02-20 mm of mercury in 1 atm of the mixture.

British Journal of Applied Physics : Volume 10, No. 5

SPECIAL ARTICLE

Superconducting computer elements. By E. H. Rhoderick.

A survey is made of the present status of superconducting circuit components, including both active elements of the "cryotron" type and passive elements such as persistent current memory cells. The factors which affect the speed of operation of these devices are discussed, and the future shown to be closely linked with developments in the technology of thin metallic films.

ORIGINAL CONTRIBUTIONS

High-resolution shadow-casting technique for the electron microscope using the simultaneous evaporation of platinum and carbon. By D. E. Bradley.

Conventional shadowcasting techniques using heavy metals as shadowing materials suffer from a limited resolution imposed by the granulation of metal. The paper describes a method for the simultaneous evaporation of platinum and carbon. This produces a deposit which does not granulate but at the same time has the high electron scattering power required for shadowing purposes. The properties of the deposit relating to its suitability as a shadowing material are fully discussed. The method is illustrated by means of various applications, one of which, the cleavage face of a sucrose crystal, exhibits monomolecular steps 11 Å high.

Flow of heat in a composite solid. By T. P. Newcomb, A.Inst.P.

A solution is given to the problem of heat conduction in a composite solid consisting of two infinite slabs between parallel boundaries, when the interface is subjected to a thermal flux which decreases linearly with time, whilst at the two outer parallel boundaries there is no flow of heat. No assumptions are made concerning the way the heat is shared between the two bodies. This solution is applied to the problem of braking with uniform deceleration and possesses the advantage over previous solutions in that it can be used even when the brake applications are of long duration (over ten seconds). Typical curves showing the transient temperatures developed during braking are given.

Deposition of unipolar charged aerosol particles by mutual repulsion. By W. W. Foster, A.Inst.P.

A simple theory of the deposition of unipolar charged aerosols by their mutual repulsion is developed. The application of this theory enables the average radius and the average charge of the particles to be determined from measurements of the mass of smoke deposited on metal surfaces and the charge given up by the particles. This new method offers a means of determining the rate of coagulation of unipolar charged aerosols. Experiments with wood smokes indicate that the simple theory of deposition is correct. The calculated average radius of the wood smoke particles examined compares favourably with that determined from measurement of the optical density and mass concentration of the smoke. The charge determined by the new method is consistent with that calculated on the basis of corona charging theory.

Viscous properties of thixotropic materials. By D. G. Osborne, A.Inst.P., and S. Thornton, F.Inst.P.

Measurements have been made on the viscous properties of thixotropic suspensions of titanium dioxide pigments in linseed stand oils. The effects of changes in concentration and temperature have been noted. The viscosity under steady flow conditions cannot be adequately defined by a single coefficient but it is convenient to display the results graphically, plotting shear stress against velocity gradient. It is shown that the shear stress required to maintain any steady velocity gradient has two components, one being independent of temperature and the other proportional to the viscosity of the medium as this changes with temperature.

The samples studied took some time to attain steady conditions of flow and the approach to this state, the "thixotropic relaxation," occurs in a very complicated way. Two qualitative conclusions could be drawn : that the magnitude and speed of thixotropic change decreased with increasing values of shear stress, and that the magnitude and speed of thixotropic change (at the same shear stress) increased with increasing concentration.

Amplitude corrections for vibroscope measurements. By Ian M. Stuart.

The dependence on amplitude of the fundamental resonant frequency for the free vibration of a string is derived for the two systems of mounting used in vibroscope measurements. It is found that in both systems a correction term of order

$$\frac{1}{\epsilon}\left(\frac{A}{l}\right)^2$$

applies, where A is the amplitude, l the gauge length, and ϵ a number we call the incremental strain. As this strain ϵ is usually small (of the order 1% from most textile testing), the correction term can be important at apparently low amplitudes.

Investigation of Nylon "texture" by X-ray diffraction. By K. Little.

The manner in which minor changes in the molecular and crystalline arrangement are mirrored by corresponding changes in the X-ray diffraction pattern has been used as a method of following the effects of a number of treatments and modifications in the structure and composition of the Nylons. The crystalline diffraction pattern was taken from the branches of spherulites. Ageing after spinning from the melt, caused by the dissipation of strains (a fairly rapid process for the first two days) and uptake of water from the atmosphere (a process completed in 50 min.), shows as increased distortion and crystallinity.

The effect of swelling agents is to relieve strain and convert to the more stable α form. Phenol acts as a swelling agent in concentrations greater than 2%. The effect of introducing side-chains is to decrease the probability of links between main molecular chains (e.g. hydrogen bonds) and at the same time decrease the probability of plastic flow, so that greater reversible extensibility (i.e. rubber-like elasticity) results.

The diffraction pattern of 11 Nylon, $[(CH_2)_{10}\text{–}NH.CO\text{–}_n]$, is consistent with the unit cell

$a = 9{\cdot}6 \pm 0{\cdot}5$Å	$\alpha = 72 \pm 2°$
$b = 4{\cdot}2 \pm 0{\cdot}2$Å	$\beta = 90$
$c = 15{\cdot}0 \pm 0{\cdot}2$Å	$\gamma = 63\frac{1}{2} \pm 1°$

Inductance of an eccentric tubular conducting system. By E. E. Jones.

The inductance of an eccentric tubular conducting system is determined in a form suitable for easy application as a power series, having the distance between the axes of the two tubes as variable. The first three terms of the series are determined in closed form, and further approximations, if required, can be determined by solving in échelon certain ordinary simultaneous algebraic equations which sum up the boundary conditions of the problem. Numerical results are included in particular cases.

Image fluctuations in cascade intensifiers. By L. Mandel.

The root mean square fluctuation of the number of photons emitted from the output screen of a cascade image intensifier is calculated. It is shown that the percentage fluctuation exceeds that of the primary photoelectrons by a small factor depending on the light gain per stage.

A.E.R.E. HARWELL

Plasma Diagnostics

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*** Methods so far used include :**

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WESTERN REGIONAL HOSPITAL BOARD

REGIONAL PHYSICS DEPARTMENT

Applications are invited from graduates in physics for the appointment of SENIOR PHYSICIST, to lead a small team working on scientific and technical problems associated with heart-lung machines and other apparatus used in cardiac surgery. Previous experience in this field is not necessary, but candidates should have a sound knowledge of electronics and a few years' experience in a research or development laboratory. Ample laboratory facilities and experimental assistance will be provided and special training will be arranged if necessary. Salary will be on the scale £1,140 – £1,550, with superannuation. Applications should be sent, before May 31, 1959, to the Secretary, Western Regional Hospital Board, 64 West Regent Street, Glasgow, C.2.

BIRKBECK COLLEGE

(University of London)

Session 1959-60 begins Monday, October 5, 1959

Part-time (evening) courses provided for Internal degrees in the Faculties of Arts and Science. Facilities also provided for full-time and part-time students reading for

(i) Higher degrees by thesis in Arts and Science,

(ii) M.A. and M.Sc. Mathematics and M.Sc. Crystallography by examination.

(iii) Academic postgraduate Diplomas in Psychology and Numerical Analysis.

The College also invites applications from full-time and part-time students wishing to take by thesis higher degrees in Statistics.

The Department of Scientific and Industrial Research has accepted the Postgraduate Diploma courses in Psychology and Numerical Analysis, and the M.Sc. Crystallography course, as suitable for tenure of its Advanced Course Studentships. Students intending to read for Higher Degrees in Science by thesis are invited to enquire of the College whether it has available any D.S.I.R. Research Studentships. Applications for admission to the College should be made before June 1. Pamphlet and form of application may be obtained from the Registrar, Birkbeck College, Malet Street, W.C.1.

UNIVERSITY OF HONG KONG

Senior Lectureship in Physics

Applications are invited for the above post, following the retirement of lecturer. Applicants should be graduates of a British University or have equivalent qualifications and experience.

Annual salary (superannuable) is £2,000 × £75 – £2,300 for a man or £1,500 × £60–£1,740 for a woman. There is also an expatriation allowance of £250 a year if applicable. The equivalent of income tax in the Colony is comparatively low.

First-class sea passages are provided for expatriate staff and their families on first appointment and leaves.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Hong Kong and London, on June 15, 1959.

PHYSICAL METALLURGIST

Division of Physics

Commonwealth Scientific and Industrial Research Organization, Australia

Applications are invited from METALLURGISTS and PHYSICISTS with Ph.D. or honours degree and experience in solid state research to work with the Solid State Group of the Organization's Division of Physics, National Standards Laboratory, Sydney. The group is studying the transport properties of pure metallic elements, binary alloys; dielectric solids of temperatures from 1°K upwards ; also heat capacities, expansion coefficients and paramagnetic resonance. The appointee is required to help and advise the group with preparation of alloys, purification of metals, controlled deformation and metallurgical examination of specimens.

Salary : dependent on qualifications and experience with the ranges £A1,326 – 1,951 p.a. or £A2,061 – 2,336 p.a.

Fares paid. Details of duties, conditions, etc., may be obtained from Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, to whom applications, quoting Appointment No. 770/172 PM, should be addressed by May 30, 1959.

PHYSICIST required to join an enthusiastic research group engaged on the application of new techniques and materials to long term investigations into machinery design, material processing and component development in the Shoe (and other) industries. Informal personal relationships with stimulating atmosphere encouraging creative ability. An imaginative approach and the ability to apply fundamental principles are considered more important than any particular background. The position offers a secure career and good prospects, with a starting salary of up to £1,100 per annum. The company is a progressive engineering company employing over 4,000 on a five-day week.

Housing difficulty recognized. Pension scheme.

Write giving full particulars of age, qualifications and experience to, The Staff Manager, The British United Shoe Machinery Co. Ltd., Union Works, Belgrave Road, Leicester.

SOLID-STATE RESEARCH AND DEVELOPMENT

An expanding research establishment situated in a country district in South Northants requires GRADUATES IN PHYSICS, CHEMISTRY AND METALLURGY to join groups working on the properties of semi-conducting materials, and also on the development of new devices.

A bias of interest towards basic studies in the solid state is required, and experience with semi-conductors would be an advantage. Some of these posts are of a more senior nature, and selected candidates will be invited to lead small groups working on fresh projects. Starting salaries related to qualifications and experience. When replying please quote as reference Solid State RD/4. Personnel Dept., The Plessey Co. Ltd., Caswell, Nr. Towcester, Northants.

UNIVERSITY OF READING

A.E.I. RESEARCH FELLOWSHIP

Applications are invited for a Research Fellowship sponsored by the Associated Electrical Industries and tenable in the department of physics. The work in the department covers a wide range of topics in solid state physics, particularly on surface effects in semiconductors and the effects of high energy radiation on the properties of solids. Both experimental and theoretical Physicists are eligible. The successful applicant will be expected to carry out research on his or her own initiative. Applicants should have had at least three years' research experience. The salary will be in the range of £700 to £1,000 p.a. The Fellowship is normally tenable for three years, from October 1, 1959, but an application from a person who wishes to hold it for a shorter period will be considered. Applications should be sent to the Professor of Physics, Physics Research Laboratory, Upper Redlands Road, Reading, Berkshire, not later than June 8, 1959, or June 15, in the case of candidates from overseas.

CENTRAL ELECTRICITY GENERATING BOARD

ASSISTANT ENGINEERS and PHYSICISTS required at the Research Laboratories, Leatherhead, Surrey, to work on problems associated with electrostatic precipitators and with heat exchangers for nuclear power stations. In both cases much of the work will be of a fundamental nature, carried out on pilot-scale plant, and importance will be attached to a sound basic knowledge.

Salaries will be on scales within the ranges, £1,195–£1,775 p.a. or £570–£1,300 p.a. according to duties and responsibilities.

Candidates for the higher grade vacancies should have an honours degree with previous research experience ; for the other vacancies a pass degree or H.N.C. would be acceptable.

Application forms obtainable from Personnel Officer, 24-30 Holborn, London, E.C.1, should be completed and returned by May 31, 1959. Please mark envelopes "Confidential Ref. P.B./46A."

UNIVERSITY OF SYDNEY

LECTURESHIP IN PURE MATHEMATICS

Applications are invited for the above position.

The salary for a Lecturer is within the range £A1,500 × £90 – £2,100 per annum, plus cost of living adjustment and will be subject to deductions under the State Superannuation Act. The commencing salary will be fixed according to the qualifications and experience of the successful applicant. Under the Staff Members' Housing Scheme in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on June 20, 1959.

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